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Contents

Cephalometric Analysis And Synthesis

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It is with great humility that I stand before you today discussing a subject which Dr. William Downs pioneered to world recognition.

It was my good fortune to spend five years with Dr. Downs at the University of Illinois. The first year, I was a student and the remaining four an assistant under him, Dr. Brodie and the other staff members. That time afforded me the opportunity to appreciate the genius of Downs and grasp the vision of his thinking. He possessed the keenest insight for the use of the cephalometric tool in diagnosis, growth analysis and planning of treatment. Whatever fruit I have borne has been from the seeds of thought planted at that experience. That time was not without constant reminders by Dr. Brodie of the need for a continuous appreciation of the deep biologic aspects and the dangers of making dogmatic statements when considering the cephalometric film.

Only so few years ago, many men were utterly confused by the role cephalometrics was to occupy in their clinical practices. The question was frequently asked "What do you men get from the cephalometric film that we don't get from clinical examinations, models and photographs?" Even with all our training and appreciation of this tool, it was found difficult to answer in a cogent manner. I shared the deep conviction with Downs that cephalometrics had a great future for the clinical orthodontist. However, my thinking had to be clarified and several answers had to be found for myself for questions that arose from a practical viewpoint.

After some years of deliberation and attempts to apply this tool, it finally crystallized, at least for teaching purposes, into five distinct aspects. These were (1) the equipment and technique, (2) radiographic interpretation, (3) cephalometric analysis or the survey, (4) evaluation of growth and the treatment results and (5) cephalometric synthesis or treatment planning. Each of these divisions, I thought, should be approached as a separate subject.

The intent of our exercise today is to review the purpose and usefulness of the cephalometric survey and to stress the use of this technique in treatment planning and estimating growth. We shall therefore delete the material on technique, interpretation and growth evaluation and concentrate on analysis and synthesis.

REASONS FOR ANALYSIS

Simply calling a dimension "large" or "small" or "good" or "bad" does not mean the same to everyone. In order to be *critical* and descriptive, it is more useful to express dimensions in terms of angles or linear measurements. Thus the purpose of analysis is *objective* and encompasses the four "C's" of cephalometrics. These are (1) to *characterize* or describe the conditions that exist, (2) to *compare* one individual with another or the same individual with himself at a later time, (3) to *classify* certain descriptions into various categories and (4) to *communicate* all of these aspects to the clinician, to a fellow research worker or to the parent.

Read before the Reunion Meeting of the Illinois Alumni, Chicago, March, 1960.

In the final analysis, the orthodontist seeks a description of conditions as recorded in the film for the purpose of understanding and communicating the nature of a problem. As Downs stated, "These problems are sometimes skeletal and are sometimes dental and therefore an organization must be made of the factors to be described".

Many clinicians failed to grasp the significance of Down's method.[1,2,3] His primary intention was to describe facial and denture relationships. In the beginning even only ten measurements tended to be confused and complicated. Many looked toward simpler techniques in seeking guides, formulas for answers for their clinical problems. They often lost sight of the primary function of the method which was to interpret skeletal morphology.

Years of thinking went into Downs' analysis before it came to the attention of the profession. His work still stands as an accurate description of the skeletal and dental relationship in late adolescent children with normal occlusion. His nomenclature for classification is an outstanding and original contribution and rates, in my opinion, with Angle's original classification of dental relationship.

With the above observations in mind, we started with the Downs analysis, and, rather than casting it aside, tried to shorten and revise it for our own purpose as applied in a busy clinical practice. We felt that the reasons for each measurement needed clarification. Of primary concern for an interpretation of the orthopedic problems of the face were measurements of facial convexity and height or depth to the facial skeleton. Facial contour needed to be assessed first in terms of location of the chin and secondly, position of the maxilla to the profile. Simple denominators for these factors were sought, i.e., chin location and profile contour.

A meaningful and simple method of describing anterior tooth relationship was desired. In addition, communication of lip relationship needed implementation.

It was recognized that all orthodontic cases did not possess normal faces as described in many studies of normal individuals. Indeed, many cases would never, nor should they, display facial patterns falling in the range of normal samples. For that reason we set about to accumulate one thousand consecutive orthodontic cases in an effort to find the range of problems and characteristics of common problems that face the clinician. The author therefore refers to some of his previous studies for reference for the related material.[4,5,6] In essence these cases averaged about age nine years, were nearly sixty per cent female and were about sixty per cent Class II malocclusions.

Cephalometric Analysis

A. *Skeletal Relationship*

1. *Facial Convexity as Determined by Point A to the Facial Plane*

After many years of debate I concluded that a direct measurement of point A to the facial plane was a useful description of contour to the bony profile. Therefore, instead of Downs' angle of convexity expressed in degrees from a straight line, we made a direct measurement from a straight line (Figure 1). In the study referred to above the average orthodontic case fell 4.1 mm anterior to the facial plane with a standard deviation of $\pm$ 2.8 mm. This revealed that only seventeen per cent of the cases demonstrated from 7 to 12 mm of convexity to the facial profile or were cases severely convex. In spite of the argument of "chin buttons" and "secondary sex changes" at the chin, we agreed with Downs by employing pogonion for convexity. We felt

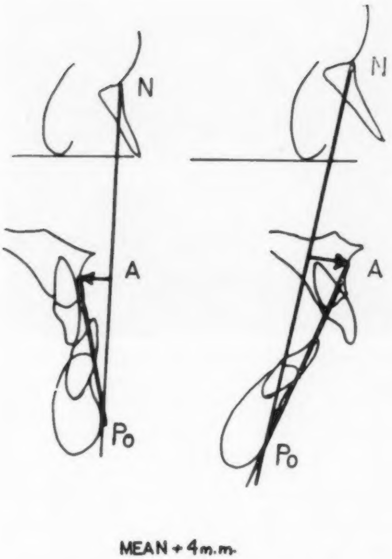

Fig. 1 Variation of bony convexity by direct point A to facial plane measurement. Mean was 4.1 mm with a standard deviation of ±3.0 in one thousand cases. Concave face on left is —8 mm, convexity on right is +10 mm. Note A to pogonion line, the variation of upper incisor relationship to the APo plane and similarity of lower incisor relationship to that line.

that measuring point A directly to the facial plane was a reliable method of expression of facial convexity in spite of size differences in facial height. Point B was not employed in the consideration of facial convexity because it was thought to represent an alveolar point on the mandible and was often misleading in the assessment of true basal convexity. Point A could be challenged for the same reason; however, it was the best representative anterior landmark for basal bone that we could consistently locate. Many orthodontists presently employ the SNA-SNB difference to describe convexity. Usually one degree is equal to about one millimeter on an arc at the distance from N to A.

2. *The X Y Axis Angle as an Estimation of Facial Height*

Downs employed the crossing of the Y axis to the Frankfort plane in typing the face. However, the entire reliance on one plane merely enforces an error if there is certain variation within the Frankfort plane. As an adaptation from midsagittal laminagraphic studies we therefore went back to basion (Figure 2), and to Huxley's basion-nasion plane and measured its crossing of the Y axis as a means of describing height to the face. We called this the X Y axis angle to distinguish it from the Y axis as measured from Frankfort plane. This seemed to be more critical and descriptive and more useful in *assessing facial height* and *prognosing the direction of growth of the face.* In the one thousand clinical cases the mean was +3° with a standard deviation ±3° (Figure 3). Thus, cases displaying angles less than 90° when measured at the crossing of the Y axis to the basion-nasion plane were suspected of possessing long faces or of being consistent with retrognathic patterns. The cases revealing readings

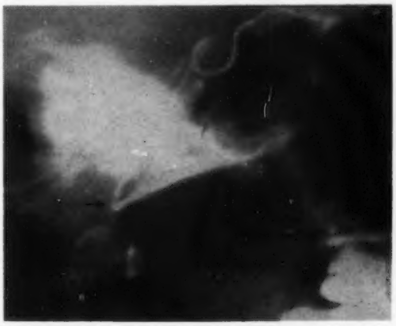

Fig. 2 Laminagraph of midsagittal section. Base of occipital bone narrows to point at the foramen magnum which is basion. Note the clivus and roof of nasopharynx converge at that point. The spheno-occipital synchondrosis is just closing in this thirteen year old girl. Note further the dens and cross section of the anterior arch of the atlas. Arrow is at basion.

greater than 90°, i.e., +6 to +10, showed more favorable characteristics. Cases yielding X Y axis angles greater than 10° to 12° were usually suggestive of closed bite tendencies in the face with short facial vertical dimension.

It should be remembered that an angle theoretically expresses proportion while direct measurements express direct comparisons. Therefore the X Y axis angle is only proportionate and does not measure true length of the face.

3. *The Facial Angle as an Expression of Facial Depth*

The facial angle is accepted as a sensible indicator of depth to the chin. Certain errors of interpretation should be avoided in cases having unusual locations of nasion, small orbital cavities or anomalies in the temporal bone.

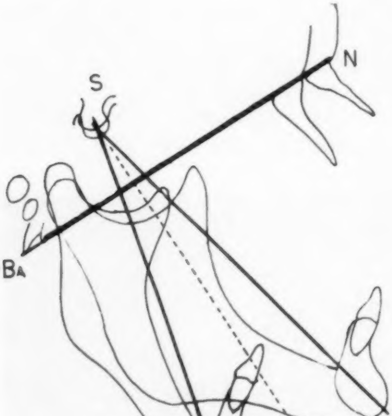

Fig. 3 The XY axis or growth axis. Location of the chin, upward and downward, is determined as SGn crosses the basion-nasion plane. Mean (dotted line) was +3 degrees of a right angle, S.D. ±3 degrees. Cases illustrated ranged from +14 degrees to —12 degrees. This parameter is excellent for typing relative length of the face.

Fig. 4 Demonstration of an unusual downward and forward ear rod location to the ear canal. This was probably an error in positioning of the patient, however, a great variation has been observed. This has led the author to employ the superior point of the dark outline of the ear hole for the posterior limits of the Frankfort horizontal plane. This has therefore prevented the human error of using the machine porion. The ear rods are held in wooden upright supports which are almost radiolucent and help increase the visibility of the joint and basicranial elements.

However, any other measurement to represent facial depth would be fraught with the same anatomical variation and limited to the same degree but would not be as easy to visualize from a right angle and externally. One frequently expressed problem was the use of the machine ear post porion which could vary considerably. Therefore, as a carryover from laminagraphic studies we employed the true ear hole and located a point at the top of the external auditory canal as the posterior limit of the Frankfort horizontal plane (Fig. 4). This was essentially the only change made from Downs' method for this measurement.

The mean in one thousand clinical cases in facial angle was 85.4° with a standard deviation ±3.7. A facial angle near 80° or below suggests a weakness of the chin and possibly poor prognosis in growth. Facial angles 90° or greater suggest a strength to the chin with bet-

ter growth prognosis. Thus, the facial angle provides a more *critical* estimation of chin position than could be gained by visual inspection or clinical examination at the chair.

4. *The Breadth Angle and Mandibular Plane Angle in Judgment of Facial Width*

Usually the combination of the facial angle and the X Y axis will locate the chin and suggest mandibular form, but an expression of breadth to the face must of necessity be proportional. After many years of deliberation and tracing of the frontal film, (Figure 5) a simple denominator for mandibular width has been used clinically to a limited degree. A point on the midsagittal plane between the two foramen rotundum was selected as registration point. Gonion and menton were marked and the angle R-Go-M was measured. The degree in this angle theoretically expresses proportional width at the gonial angle. Measurements near 80° were the average type of condition observed. In wide, square mandibles this reading might be as low as 70° while in narrow mandibles and long faces, this angle will be as high as 90°. Certain corrections can be made for this angle in order to over-

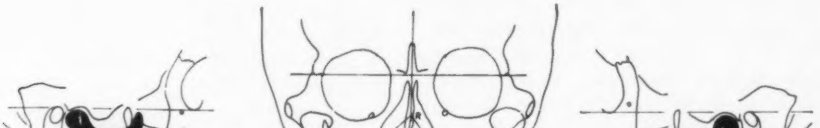

Fig. 5 Tracings of the frontal film and right and left laminagraphs of joint and mandible. Shows measurement of facial form and asymmetry in the frontal film and demonstrates factors in mandibular growth and form. Above — angle RGoM is 85 on left (undergrowth) and 80 on right (normal). Mandibular plane angle on left is high at 31 degrees, on right it is low, 21 degrees. Note the posterior tilt of the condylar neck and head in the upper left figure.

Below — angle RGoM is 77 degrees on left (normal) and 70 degrees on right (overgrowth.) Note the difference in the mandibular plane and condylar form in the two tracings. The condylar neck is upward and forward and thick and heavy in the lower right figure.

come an error of tipping of the head at the x-ray exposure if one was noted.

A secondary representation for facial width is seen in the mandibular plane angle. The mean in the one thousand cases was 25.7 with a standard deviation of ±5.9°. Low mandibular plane angles (20° or less) usually suggest closed bite tendencies with forward growing tendencies while high mandibular plane angles (38° or more) are usually consistent with patients showing vertical expression in growth.

B. *Dental Relationship*

1. *Denture Plane—Reciprocal Relationship of the Lower Incisor*

Probably the greatest controversy with the use of cephalometrics has been its use as a guide in evaluating the relationship of the incisor teeth. Downs selected the A-pogonion plane as the line connecting the most anterior limits of basal bone of the maxilla and the mandible (Figure 1). He measured the upper incisor from this line, a method which we have not changed. However, a more useful and descriptive capacity for the A-pogonion plane is the measurement from the lower incisor. Downs measured the lower incisor to the A-pogonion plane in his normal group and found it to be located in a range from 2 mm backward to 3 mm forward of the plane. Its average axial inclination was 23° with a standard deviation of ±3°. In the one thousand case study referred to above we found the mean to be almost +0.5 mm forward of the A-pogonion plane with a standard deviation of about 2.5 mm[4]. This orthodontic sample thus spread with one standard deviation the entire range of Downs' normal sample. It averaged almost an identical position in spite of our sample being orthodontic and his being selected normals (Figure 6, above). Other samples studied at our suggestion were the fifty normals from

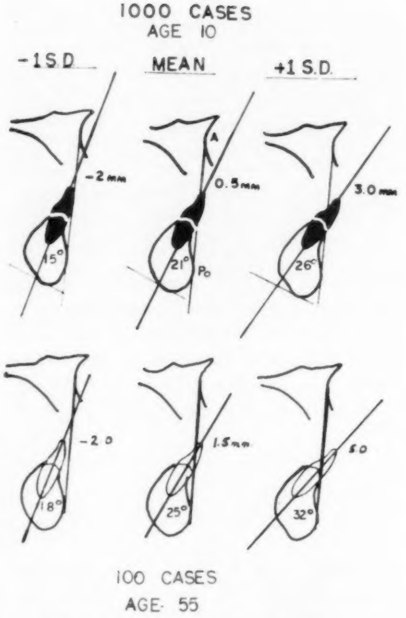

Fig. 6 Studies of the position and angulation of the lower incisor.

Above — Mean and variation of one thousand cases which are almost identical to Downs' normals. Lower incisor average is .5 mm ahead of APo plane at 21 degrees, standard deviations of ± 2.5 mm and ±5 degrees respectively yield —2 mm at 15 degrees to +3 mm at 26 degrees as range of objectives in treatment.

Below — Findings on one hundred untreated cases at age fifty-five. Note more forward position of 1.5 mm at 25 degrees. The range of acceptable relationship here would yield —2 mm at 18 degrees to +5 mm at 32 degrees. This is consistent with range of treated cases in the author's practice.

In treatment the upper incisor is related from the lower incisor to a normal overbite and overjet at 130 degrees to 145 degrees depending upon age and type.

Indiana University (Shudy[7]) and a sample of thirty prize winners in "Smile of the Year Contests" in Los Angeles city schools (Hopkins[8]). These groups displayed lower incisors averaging 1.6 and 2.3 respectively, forward of the A-pogonion plane.

Ricketts and Chase[9] investigated a

cross section of one hundred patients at the Los Angeles Veterans Hospital in order to determine the position of the lower incisors in patients retaining their teeth to the sixth decade of life. (Figure 6 below) The lower incisor in that sample of older age was strikingly similar to normal samples of Shudy and Hopkins. The mean lower incisor was found at -1.4 mm to the A-pogonion plane with S. D. of ± 3.4. The average inclination of the incisor was $25.4^\circ \pm 6.8^\circ$.

These findings certainly cast doubt on the validity of samples selected for esthetic purposes only which locate the lower incisors backward of the A-pogonion plane. Normal cases thus can be observed with a backward relationship of the denture. Prominent dentures "attract" attention and are attractive. It should not be inferred that these prominent teeth are unstable; in fact this is an oft-repeated assertion without apparent documentation. Possibly this idea stems from experiences of over expansion but is not applicable to non-treated cases.

It should be borne in mind that with greater convexity of the face, the inclination of the A-pogonion plane is forward. The lower incisor tooth often tilts forward in compensation, hence the "reciprocal plane". It is therefore our opinion that, for purpose of analysis, the A-pogonion plane serves as the best reference line for describing the position of the incisors that is available because it *relates teeth to the composite bases.* Measuring to the NB line in effect is relating the lower incisor to itself because the position of B is determined by the lower incisor in the first place. A measure of the axial inclination to Frankfort horizontal does not describe its spatial relationship but only its uprightness to a straight profile and does not consider convex or concave faces which are often experienced. Also, a relation of the teeth to the line NB or to NA does not take into account facial configuration nor age of the patient. Thus compromises must be made which become confusing and involved. The use of the A-pogonion plane as a reference plane satisfies the requirements for facial types and provides for the difference in the growing individual, i.e., the lower incisor tends to retract at the same rate that the profile straightens.

The only objection to the use of A-pogonion is the so-called "chin button" case. These are overrated in frequency and can easily be dealt with by simply considering the chin and maintaining a posterior relation of the tooth if necessary.

2. *Esthetic Relationship as Evaluated from the Esthetic Plane*

It was recognized some years ago that some criteria were needed to communicate differences in the relationship of lips to contiguous structures. Therefore a line similar to the anterior limits of the basal bone was selected in the soft tissue, namely, the end of the nose and the end of the soft tissue of the chin (Figure 13). This line was termed by us[10] to be the "esthetic plane" and was employed only for the purpose of describing the relationship of the mouth to other structures. Due to anatomical variation and age differences no fixed requirements have been laid down. However, it has been observed that patterns revealing lips protruding ahead of this line have been evaluated by most orthodontists to be disproportionate and fraught with facial disharmony. It is our feeling that by adulthood the lips should be contained within the nose-chin line for cosmetic purposes. In addition, this line is useful in evaluating the functional abnormalities of the lip which have been

described by us.

C. *Deep Structures Explain Profile Variation*

Deep structural analysis includes (1) the cranial base, (2) the temporomandibular joint and mandibular ramus, and (3) the nasopharyngeal framework together with the pterygoid plates.

Cephalometric Synthesis

Probably the greatest difficulty in the understanding of cephalometrics has come regarding its use in treatment planning. It must be emphasized that the description, classification and communication of the problem is one subject, that of diagnosis. Treatment planning is an entirely different subject. When treatment is planned the clinician must take into account a knowledge of growth and alteration of structure. He also needs familiarity with the possibilities of tooth movement together with a comprehension of the anchorage values of teeth. Finally, he must anticipate the changes of soft tissues that accompany changes in the teeth in order to perceive the functional and esthetic end result.

It is evident, therefore, that treatment planning should take into consideration many changes, and these be predicted by the clinician if he is to fully appreciate the possibilities that are at his disposal by various mechanical or functional techniques. Any treatment plan constitutes a prediction of change whether the orthodontist likes to admit it or not.

A. *The Static Synthesis — (No Growth)*

When no growth is anticipated, the estimation is made almost entirely for the movement of the teeth and changes in lips. The headplate tracing is employed as an instrument to visualize estimated tooth movement. The desired and expected changes are synthesized in a new tracing. A useful guide for envisioning changes of the anterior teeth is the A-pogonion plane or the "reciprocal denture plane". The teeth are planned to be placed according to the forces or oral environment that create balance, i.e., the tongue and the lips. A requirement for final lip relationship is that the lips fall within the esthetic plane, that the lips are smooth in contour and that the mouth can be closed with little or no strain. Remember the static case is not expected to grow out of a lip imbalance.

Esthetics is considered an integral part of orthodontic planning; usually, when the requirements for esthetics are satisfied, the teeth will be in good functional relationship. Contrarywise, when the teeth are well related, the lips will fall into good esthetic and functional harmony. Therefore we try to place the lower incisor within one standard deviation of the normal to the APo line depending upon oral and environmental factors, i.e., 0.5 mm. ±2.5 mm. However, we may intentionally err toward protrusive relationship in some patients due to expected late growth changes. The upper incisor is then adjusted to it with normal overbite and overjet. Common sense and clinical acumen are the final guides. After determining the desired changes in position of the anterior teeth the necessary anchorage can be envisioned by movement of the posterior teeth. Anchorage factors and treatment techniques constitute separate subjects and will not be discussed here.

B. *The Dynamic Synthesis — (for the Growing Child)*

When growth is anticipated the synthesis is dynamic. Growth of the chin in direction and amount is a foremost consideration. However, cranial areas are employed for basal references.

1. *Cranial Behavior*

SN change has been found useful because the maxilla seemed to grow forward at almost an identical rate with nasion[5]. The angle SNA changed very little in one hundred observed Class I and Class II cases with no orthodontic treatment (Figure 7). Our findings further revealed that approximately one mm per year of growth on the sella nasion plane can be expected and sella basion is usually about two-thirds of that amount. Variations showed that some cases expressed no growth, particularly girls after puberty, while others grew more than one mm per year. Although slight errors in prediction frequently were noted, the long, upturned anterior cranial base (obtuse BaSN) seemed to increase most rapidly. At any rate, anticipation on the basis of the constitution, age and sex is better than leaving everything strictly to chance and without consideration for natural development.

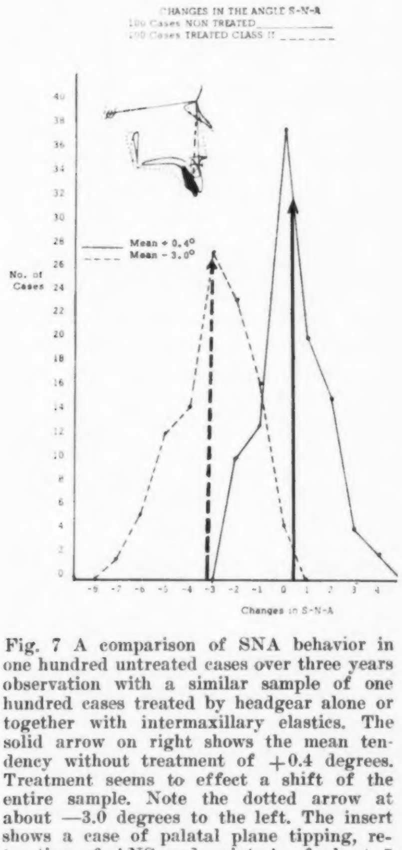

Fig. 7 A comparison of SNA behavior in one hundred untreated cases over three years observation with a similar sample of one hundred cases treated by headgear alone or together with intermaxillary elastics. The solid arrow on right shows the mean tendency without treatment of $+0.4$ degrees. Treatment seems to effect a shift of the entire sample. Note the dotted arrow at about —3.0 degrees to the left. The insert shows a case of palatal plane tipping, retraction of ANS and point A of about 5 degrees. Note the lingual torque of the upper incisor root.

2. *Mandibular Behavior*

The next step is estimating the change in the chin by the *direction* of the Y axis or growth axis of the face. The basion nasion plane is more critical

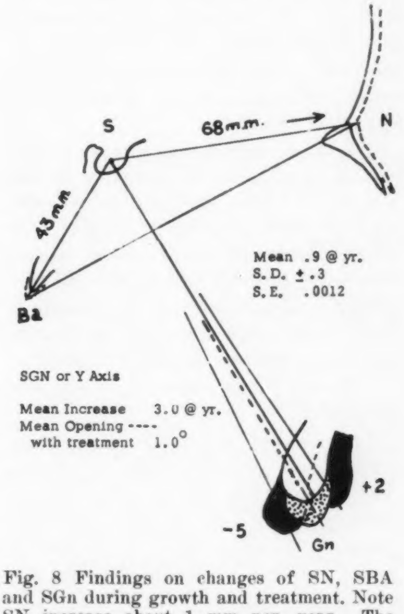

Fig. 8 Findings on changes of SN, SBA and SGn during growth and treatment. Note SN increase about 1 mm per year. The typical change in the Y axis was about 1 degree opening with treatment, see hashed line and dotted chin. Average increase in length of SGn was about 3 mm per year. Note variation of $+2$ degrees to —5 degrees change in Y axis observed during treatment in individual cases. These findings are employed for estimation in treatment planning.

but sella nasion line can be employed by those not able to find basion on the film (Figure 8).

In the average Class II case the Y axis tended to open about one degree during a two year period while the patient was undergoing orthodontic treatment. In prognathic patterns or strong mesognathic patterns the chin tended to come forward or the Y axis closed one degree or more during orthodontic treatment. In some severe retrognathic patterns, accompanied by distal positional changes of the condyle, two to four degrees opening of the Y axis was not uncommon. When this opening was due to mandibular rotation, it was thought some could be avoided by orthodontic forces which intruded the teeth. Rotation here is meant the rotation of the condyle in the fossa as the chin swings in a downward and backward arc as the bite is opened.

The final consideration for estimation of change in the direction of the Y axis therefore revolves around the original facial pattern, the manner in which the mandible is related to the remaining skeletal structures and the growth characteristics of the mandible itself. In Figure 9 are listed ten characteristics of the mandible which seem to be related to its eventual form, size and proportion.

MANDIBULAR FORM AND DEVELOPMENTAL BEHAVIOR

Mandibular Characteristic	Tendency on Ramus	Tendency on Chin
1. Mand. Plane Angle		
Low	>	>
High	V	V
2. Gonial Angle		
Acute	>	>
Obtuse	V	V
3. Width of Ramus		
Wide	>	>
Narrow	V	V
4. Thickness of Condyle		
Wide	>	>
Narrow	V	V
5. Width of Symphysis		
Wide		>
Narrow		V
6. Inclination of Condyle		
Forward	V	
Backward		> V
7. Corpus Length		
Long		>
Short		V
8. Coronoid Height		
Low	>	>
High	V	V
9. Occlusal Plane		
Parallel	>	>
Devergent	V	V
10. Ante-gonial Notching		
Normal		
Notched	Λ	V

Fig. 9 Ten characteristics which give clues to the development of the lower face. The growth of the condyle affects growth of the ramus, the body and the chin. Please compare this table with cases illustrated in Fig. 5. The proper evaluation of these factors helps predict mandibular form and facial development.

The *amount* of growth of the mandible is difficult to determine. However, the knowledge of the average case is a starting point. The average yearly expectancy is about 2.5 to 3 mm of growth on the Y axis. Five to six mm increase in length of the Y axis is the typical expression of two years growth during treatment for children at the mixed dentition and girls at puberty. Boys tend to grow at a slightly greater rate than girls except during their pubertal ages. After puberty some boys will grow at almost twice the rate of girls. Boys sometimes grow 8 to 12 mm during the two year period from age 12.5 to 14.5 or at the time they are undergoing a pubertal spurt. In functional orthopedic techniques a slight forward positioning of the condyle, and hence the chin, will confuse the picture. After a time (growth) these usually are of minor effect in most cases.

Change the Y axis and lengthen it for estimated growth, draw the symphysis and establish the mandibular plane backward from the symphysis

consistent with tilt of the mandible.

The knowledge of the behavior of the chin has much to do with the eventual outcome of the case in spite of the frequently heard expression that "all growth is good — no matter what direction it takes". All growth probably is good. However, when Class II conditions are being corrected, growth in the forward direction is unquestionably of much greater benefit than predominantly vertical development.

3. *Maxilla Behavior*

The behavior of point A from a vertical and horizontal standpoint is estimated. Point A and the anterior nasal spine usually drop vertically about one-third the total facial height increase during treatment. The contour at point A is modified by the use of extraoral traction and to a lesser amount by the use of intermaxillary elastics when accompanied by torquing action to the upper incisor teeth. Normal cases have been observed to display an SNA angle decrease of up to two degrees during an observed growth period similar to that occurring during treatment (Figure 7). These same patients treated with strong cervical anchorage have been noted to decrease seven to eight degrees during orthodontic treatment. Many cases of good prognathic growth patterns will frequently reveal an SNA angle increase of one to two degrees during a two year period. With Class II treatment as outlined above in these cases the angle SNA will not change or will decrease up to two or three degrees depending upon the forces employed.

Draw the palatal plane and point A contour behavior. This completes basal skeletal alteration in the profile (Figure 10).

Cephalometric Tooth Set Up

The desired relationship of teeth is established in the synthesized skeletal pattern (Figure 11A). Point A is connected with a line to pogonion; remember point A has been changed and the chin has grown. The lower incisor is related to this new reciprocal plane in the manner desired depending upon the *environmental* forces operating on the denture and the *age* of the patient (Figure 11B). Following the location and inclination of the lower incisor from the A-pogonion plane the upper incisor is erected to that determined best for the stability of the denture and for later growth experience (Figure 11C).

Movement of the posterior teeth is

Fig. 10 Approximately one-third height increase of the face during treatment is registered in the upper face, N to ANS. About two-thirds height increase is measured in the denture area or lower face. The palatal plane usually tilts under the influence of cervical traction and the whole nasal floor seems to be altered. Maxillary changes are estimated by superimposing on the facial plane and then SN or other cranial references.

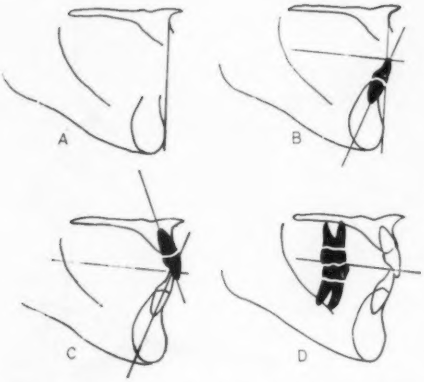

Fig. 11 Sequence of steps in establishing objectives of tooth position. A— Draw the new APo plane to establish a reciprocal line. B— Set up the lower incisor to vary from the mean depending upon individual needs. C— Locate the upper incisor from the lower, i.e., normal overbite and overjet at 130 to 145 degrees depending upon age and facial type. E— Figure anchorage on possibilities of treatment after having established the necessary anterior changes.

visualized in the projected tracing. The judgment of necessary molar behavior follows a thorough analysis of treatment of many cases treated by different methods (Figure 11D).

Finally, the estimation of the growth of the nose can be made together with the alteration of the soft tissue of the chin and the adaptation of the lips to the new position of the teeth. Here an awareness of nose growth and lip alteration with treatment and growth to fully conceived esthetic changes is necessary. The estimation of lip changes is probably the most difficult factor to master in the whole technique (Figure 12).

The study of the synthesized tracings superimposed over the original reveals the possibilities of treatment with or without extraction (Figure 13). The more accurate the technique and the more knowledge that was carried to the synthesized case, the better the treatment plan. Thus the total change in the case is demonstrated and understood (Figure 14).

Summary and Conclusions

An attempt has been made to simplify and crystallize certain ideas with regard to *clinical* cephalometrics as practiced and conceived by the author. It was speculated that much of the confusion of cephalometrics has been due to the fact that clinicians have failed to segregate different aspects of the subject. Analysis in the past has been viewed as an entanglement of angles and lines with a vague or complex application to routine problems. The purpose of a cephalometric survey, as explained, was to describe, classify and communicate the nature of skeletal orthopedic problems or dental malformations. By this means an accurate diagnosis of the case could be gained. The facial plane, the reciprocal denture plane or APo plane and the esthetic plane were shown to be useful.

One misuse of cephalometric analysis has been the error in the interpretation of standards. The tendency has been to view the headplate and attempt to determine what should be done by rearranging the teeth following a formula worked out from normals or ideal cases. Such a static concept neglects to recognize the influences of growth and alteration of structures. Thus, analysis has been mistakenly linked to treatment planning.

The ideal for the individual is simply the best that can be achieved with treatment under a given pattern and set of growth circumstances. What is ideal for one is not ideal for another. No concern was given for a case that did not fit a "normal" in every respect, indeed, that was impossible. Means, ranges of variation, conceived standards or "ideal" objectives merely formed a basis for comparison or a guide to

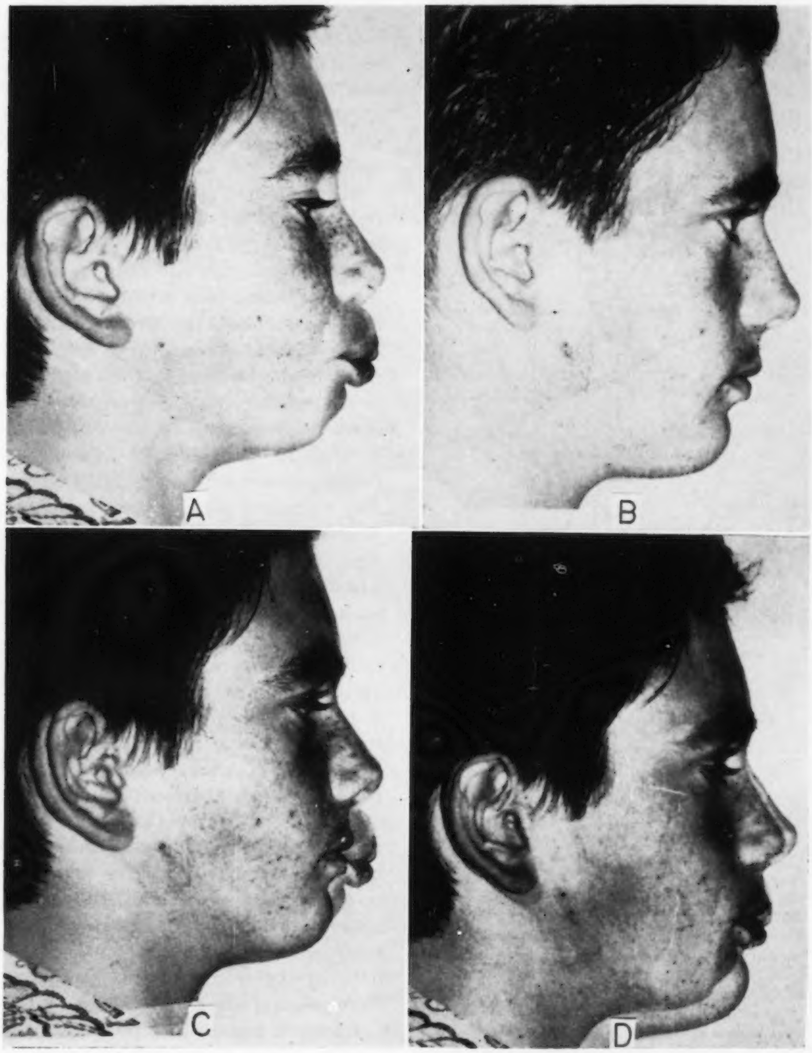

Fig. 12 Photographs before and after treatment of the case illustrated in Figs. 13 and 14. A— Severe lip strain and protrusion with lip closure before treatment. B— Lips normal after treatment, closed with no strain, smooth in contour, contained within the E plane (tip of nose and front of chin) and lower slightly forward of upper when related to the E plane. C— Case superimposed on E plane. D— Superimposed on cranial elements to show growth changes of the chin and the nose. See Fig. 14 for analysis of growth and treatment changes.

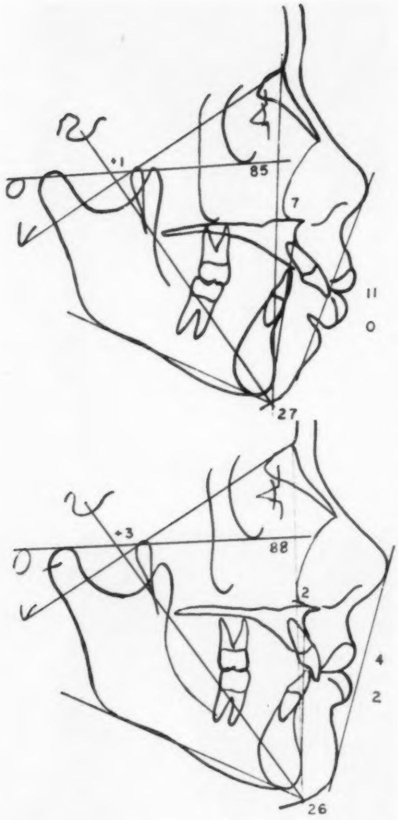

Fig. 13 Before and after tracings of the case illustrated in Figs. 12 and 14. Note the convex mesognathic pattern with severe dental and alveolar protrusion of the maxillary arch. Extraction of four first bicuspids was employed as a measure of treatment for this fourteen year old male. Notice the upper incisor protruded 11 mm anterior to the APo plane and that 7 mm of convexity was present. The lower incisor was just on the APo plane. After treatment the chin was more forward, the convexity was only 2 mm and the upper incisor was only 4 mm forward of APo. Although the lower incisor was 2 mm forward at retention, it had been retracted and intruded 3 mm as seen in Fig. 14. The original tracing was at fourteen years, five months and the second at sixteen years, eight months.

suggest the manner in which a given case differed in facial pattern, malocclusion or esthetic relationship. Analysis thus told the clinician "where he was" with a case. "Where to go" with a case is directed by an entirely different aspect of cephalometrics, that of synthesis.

If a hunter is to shoot a duck on the fly, he must lay the shot in the pathway of the duck so that the shot and the bird arrive at the same instant of time. An estimation is made of the rate of speed and direction of the flight. If a hit is scored a correct prediction was made of the physical factors involved.

To a less critical degree the orthodontist moves teeth in a growing child so that he arrives at a desired goal commensurate with anticipated change. Any treatment plan is thus a prediction of change; otherwise there would be no plan and everything would be left strictly to chance. Treatment planning with cephalometrics is based on a knowledge of *growth* and familiarity with the *possibilities* of structural alteration and tooth movement as viewed in the headplate. Cephalometric synthesis rightfully includes an estimation or prediction of changes in the skeletal framework in conjunction with the movement of teeth. However, certain types of treatment seem to affect the behavior of the mandible as far as bite opening is concerned and dramatically affect growth of the maxilla. Thus, estimation must be projected on the basis of the selection of different mechanical procedures.

Rarely a hunter can pick up a gun and hit a clay pigeon without practice. He may hit a few by accident in the beginning but it takes patience and practice in order to be proficient. Likewise, in cephalometric synthesis, it takes patience, study and practice to plan a case and hit the desired mark.

The technique outlined is compara-

tively new and much work remains to be done on a statistical basis to make it even simpler and more foolproof. As it stands it is merely an aid or a guide to help the clinician envision treatment and one should not be dismayed if things don't work exactly as anticipated. The clinician should be satisfied if he has achieved the general characteristics and appreciated the general biologic factors at work in the individual case and has been able to make a rough estimation of the case in point.

Cephalometric films can be employed for descriptions of morphology, for knowledge of growth, for outlining objectives of treatment and for utilizing advantages of different treatment techniques. Cephalometrics is another tool for aid in diagnosis and treatment planning. When used properly, cephalometrics is the most excellent tool for this purpose available today to the clinical orthodontist.

875 *Via de la Paz*

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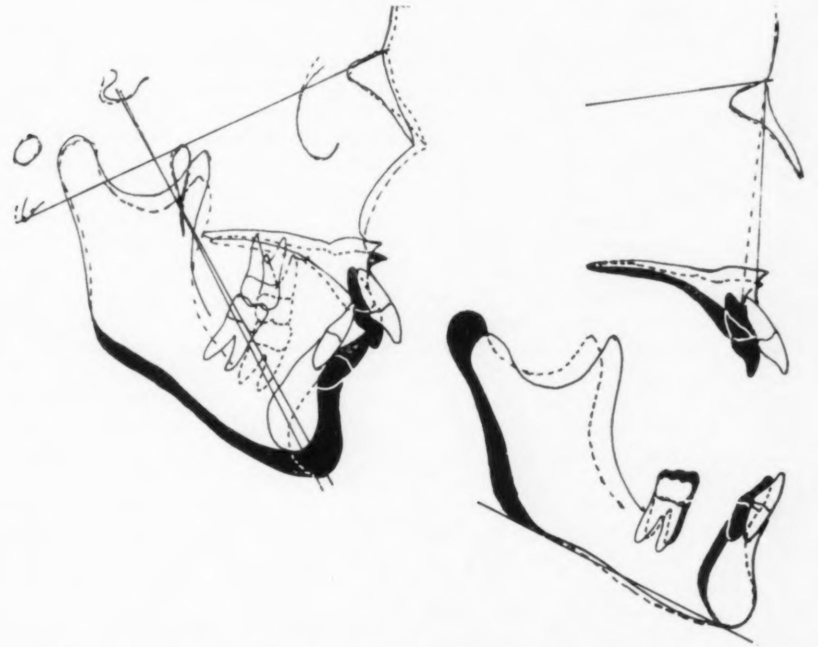

Fig. 14 Growth and treatment analysis of the above case. Note the closing of the Y axis slightly more than 1 degree and about 10 mm of SGn increase. Note the SNA decrease and upper incisor retraction, and finally the stability of the lower first molar and bodily retraction of the lower incisor. Good mandibular growth helped immensely in the conclusion of this case but it was expected, relied upon, and utilized.

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Orthodontic Case Analysis

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The many etiologic factors of malocclusion and infinite variations in the normal pattern of facial development frequently combine to make orthodontic problems complex. Case analysis includes an evaluation of the general factors affecting growth and the local factors which may affect the denture. Since treatment should be started during an active growth period, it is necessary to evaluate the existing relations of the denture to the face and to prognosticate the potential of future growth.

One of the first steps in case analysis is to observe the relations of the face by patient examination. Readily discernible and of particular interest are the mandibular plane, maxillary and mandibular base differences, disharmony in other components of the face, and the distribution and function of the musculature. The observing orthodontist will see and record a wealth of diagnostic information from this superficial examination.

To this is added the information from a case history, a study of plaster casts and intraoral examination. Of importance are discrepancies in arch length, abnormal tooth inclinations, functional patterns as evidenced by worn areas on occluding surfaces, evidences of pressure habits and the nature of alveolar bone as evaluated from x-ray and intraoral examination.

Cephalometrics supplies detailed information to supplement and verify observations already made. While it is possible to record many measurements, the most significant ones are those recording the relation of the mandible to the maxilla, the relation of the anterior teeth to each other and to their respective bases, and the angle of the mandibular plane. The interpretations made from cephalometric measurements should make diagnostic sense and should convey a consistent relation to observations made from other diagnostic criteria.

Dr. Harold Noyes has aptly described his reaction to the teaching of case analysis as follows, "Case analysis techniques fall into the training class. Because of the time element, graduate instruction has some advantage in presenting various methods, but it holds no corner on this market. There has been too great a tendency to reduce case analysis to formulas, which in some measure may be necessary when teaching students without experience. Yet with respect to analysis of the cephalometric x-ray, this has proceeded to the point where the immature orthodontist often cannot see the structure for the planes and angles. There is created a slide rule diagnostician and some years of experience may transpire before judgment replaces rule of thumb. I have been amused when listening to recent graduates discuss their problems, to hear one say that the angle is thus and such so we extract four premolars. In reality I am not too critical of this didacticism because it has been a crutch upon which the young orthodontist can lean before his clinical judgment will support him."

In some respects, with their educational background in the fundamentals

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of growth and development, and their slide rule interpretations, the present orthodontic graduates are much better equipped than those who were graduated a few years ago. Clinical judgment is an intangible sort of entity which I suspect most of us think we develop after years of experience. It undoubtedly seems to be more reliable to us when growth responses are such that they complement what we have tried to do orthodontically.

Rigid treatment standards help to produce more uniform results. However variations in the distribution of growth and the time at which such growth takes place frequently make the attainment of such goals most difficult. The strong tendency for structural relations and muscle forces to dictate the ultimate position of the denture and the axial inclinations of the teeth may be an adequate reason for not attempting to treat to a rigid concept of an ideal pattern.

An examination of the records of the following four treated cases will demonstrate the role played by variation. Tooth movements have varied greatly even though subjected to similar forces. Extreme discrepancy in the bone relations has invited what may be considered unfavorable incisor inclinations. Posttreatment growth has changed the positions to which teeth were moved in treatment. Growth that was not anticipated has had both favorable and unfavorable effects upon tooth relations and facial esthetics.

Treated Cases

Case R.S. was a boy thirteen years of age with a Class II, Division 1 malocclusion. The Downs analysis indicated a convex type of face with a tendency for a backward divergency of the mandibular area. There was a moderately good relation of mandibular teeth to structure. While this case was evaluated as being one in which it might be necessary to remove some teeth, an attempt was made to treat it without any extractions.

Edgewise appliances were used in treatment and the arch relation was changed by the use of intermaxillary elastics worn day and night for three and one-half months. Active appliances were worn for thirteen months.

An evaluation of the posttreatment records indicated a good growth response and a favorable change in structural relations. There was a 5 degree labial tipping of the mandibular incisors considered to be unfavorable. The maxillary incisor relation to the AP plane was changed from 13 to 7 millimeters. An original FMIA of 55 degrees was changed to 51 and the tissues of the lips were strained in closed position. The prognosis was considered definitely unfavorable. The unpredictability of future growth and a reluctance on the part of the patient to have the case retreated were factors which influenced me to leave the case without further treatment. The condition was retained for three years.

Additional impressions for models and photographs were taken at seventeen years of age, also cephalometric records were taken at sixteen and seventeen years of age. These later records show that very extensive growth occurred in the entire face with a swinging forward of the mandible as a result of growth. There were significant improvements in the facial plane, angle of convexity, AB plane, mandibular plane, and Y axis. The maxillary incisors which had been moved to 7 millimeters to the AP plane remained in this position. The occlusal plane was tipped during treatment from 11 to 12 degrees and went back to 10 degrees in the posttreatment period. While the mandibular incisors were tipped labially from 6 to 11 de-

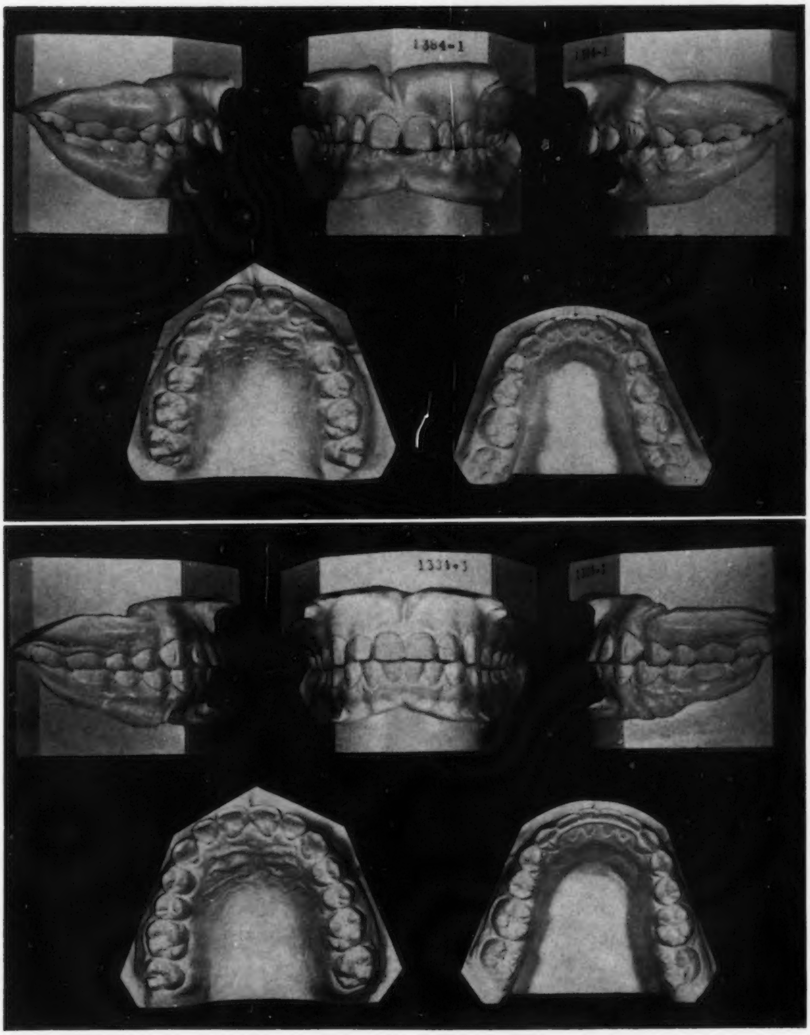

Fig. 1 Models of R. S. before, and three years after treatment.

Fig. 2 Photographs of R. S. before, after, and three years after treatment.

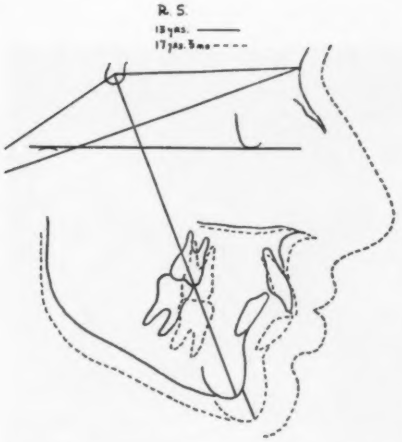

Fig. 3 Composite tracings from Downs analysis of R. S.

TABLE I

R. S.	13 years	14 years 4 months	17 years 3 months
Facial Pl.	80	82	84
Convexity	8	4	5
A-B Plane	—11	—7	—9
Mandibular Pl.	28	28	24
Y Axis	69	67	67
Occlusal Pl.	11	12	10
Interincisal	123	120	108
$\overline{1}$ to Occ. Pl.	23	27	36
$\overline{1}$ to Mand. Pl.	6	11	22
$\underline{1}$ to A-P Pl. (mm)	13	7	7
FMIA	55	51	44

grees during treatment, during the posttreatment period they continued to tip to a final reading of 22 degrees. Corresponding changes are observed in their relation to the occlusal plane, their effect on the interincisal angle and the FMIA which changed from 55 to 44 degrees.

The face which had strained tissues about the denture at the conclusion of treatment now has relaxed tissues in a good state of balance. The profile exhibits a convex type of face with sharp prominent features and tissues in good esthetic and functional balance.

The teeth have moved and have been worn into a good functioning relation. It has been recommended that impacted mandibular third molars be extracted and that when the maxillary third molars erupt they also be extracted.

Growth and adjustment are responsible for whatever may be favorable about this case. It appears obvious that when natural forces were permitted to work on the denture, they produced a much greater procumbency of mandibular incisors than was produced by treatment.

Case C.P. was a girl thirteen years and nine months of age. The occlusion was an atypical, unilateral distocclusion with crowding in the incisor area of both arches and a deep anterior overbite. The teeth were in good relation to basal structures. The FMIA was 52 degrees indicating a procumbency of the mandibular incisors. The mandibular third molars were present and in good position but maxillary third molars were not discernible. The face was most pleasing with a straight profile.

Since the girl was almost fourteen years of age, it was considered a reasonable assumption that future growth would be minor in degree. Because it was considered a borderline case in which extraction could be considered debatable, the maxillary first bicuspids and the mandibular second bicuspids were extracted.

In treatment an effort was made to move posterior teeth forward and avoid lingual tipping of the anterior teeth. Active treatment was completed in eighteen months.

The facial plane changed from 78 to 82 degrees. There was a great change

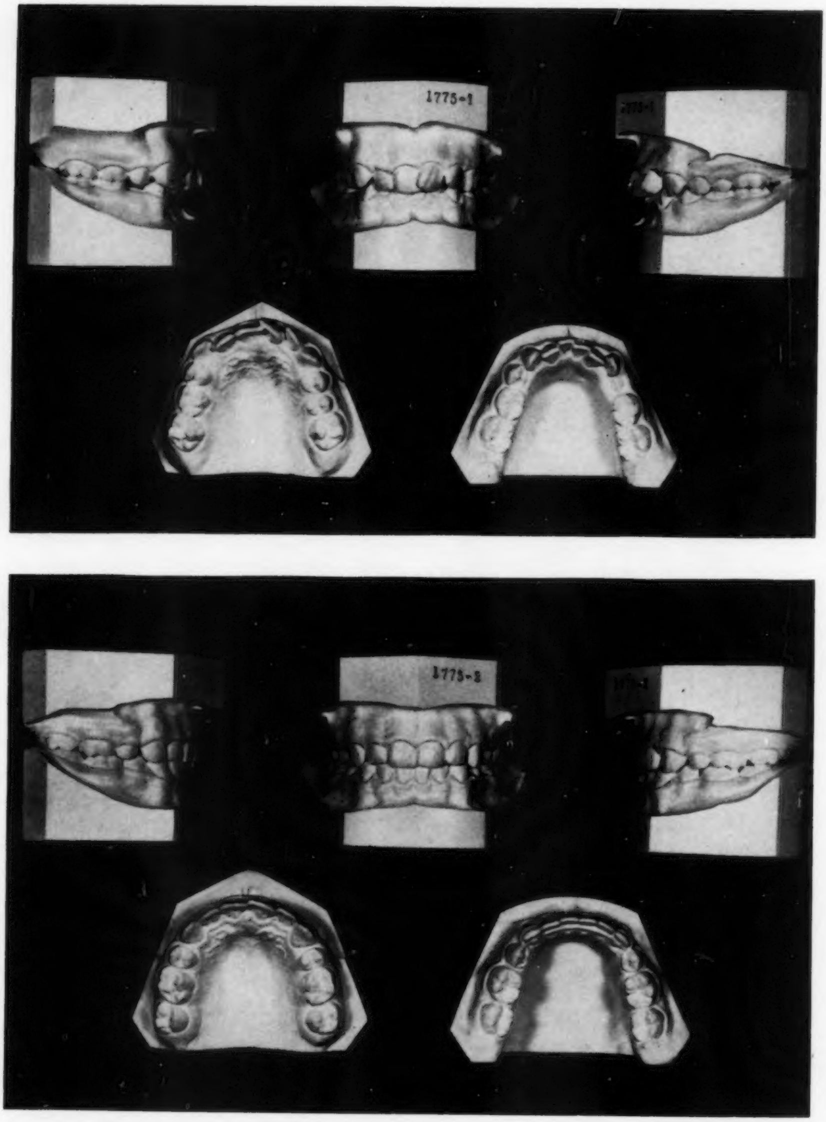

Fig. 4 Models of C. P. before and after treatment.

Fig. 5 Photographs of C. P. before and after treatment.

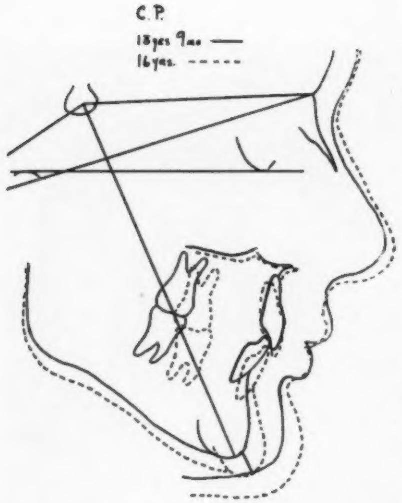

Fig. 6 Composite tracings from Downs analysis of C. P.

TABLE II

C. P.	13 years 9 months	16 years
Facial Pl.	78	82
Convexity	0	—5
A-B Plane	—7	—7
Mand. Pl.	32	30
Y Axis	67	65
Occlusal Pl.	17	15
Interincisal	143	144
$\overline{1}$ to Occ. Pl.	21	15
$\overline{1}$ to Mand. Pl.	6	0
$\underline{1}$ to A-P Plane	3	0
FMIA	52	59

in the angle of convexity from 0 to —5 degrees. There were also similar changes in the mandibular plane and Y axis which would indicate a forward position of pogonion.

The maxillary incisors were tipped slightly to the labial and their relation to the AP plane changed from 3 to 0 millimeters. The mandibular incisors were tipped lingually from 6 to 0 degrees to the mandibular plane. The combination of incisor movement left the interincisal angle one degree from the original. The FMIA changed from 52 to 59 degrees. If one were to attempt to make these teeth conform to Tweed standards, they would require lingual tipping of 6 more degrees. This being a straight face, the 65 degree FMIA should be applicable, at least more so than in a convex type of face.

The photographs taken at the conclusion of treatment showed disappointing results. The lovely, straight profile and excellent balance in the original have changed to essentially a concave profile in spite of all the precaution taken in treatment to avoid such a result.

A study of the composite tracing will show in some degree why this happened. While the lip area remained in essentially the same position, there has been considerable growth of the nose and mandible. Some growth has occurred at gonion and there is a great amount of appositional growth at pogonion.

Looking at this case in retrospect, it seems as though it would have been better to have treated it without extraction, even though some crowding were to occur in the incisor area following treatment. Without extraction there probably would be a tendency for the same change in esthetics, although less in degree. Unusual cases like this one make it difficult to predict the nature of growth or to make treatment results conform to average measurements.

Case C.R. was a girl nine and one-half years of age. She had a Class II, Division 1 malocclusion with an extreme discrepancy in the incisor area and a marked AB difference. There was crowding of teeth in both arches.

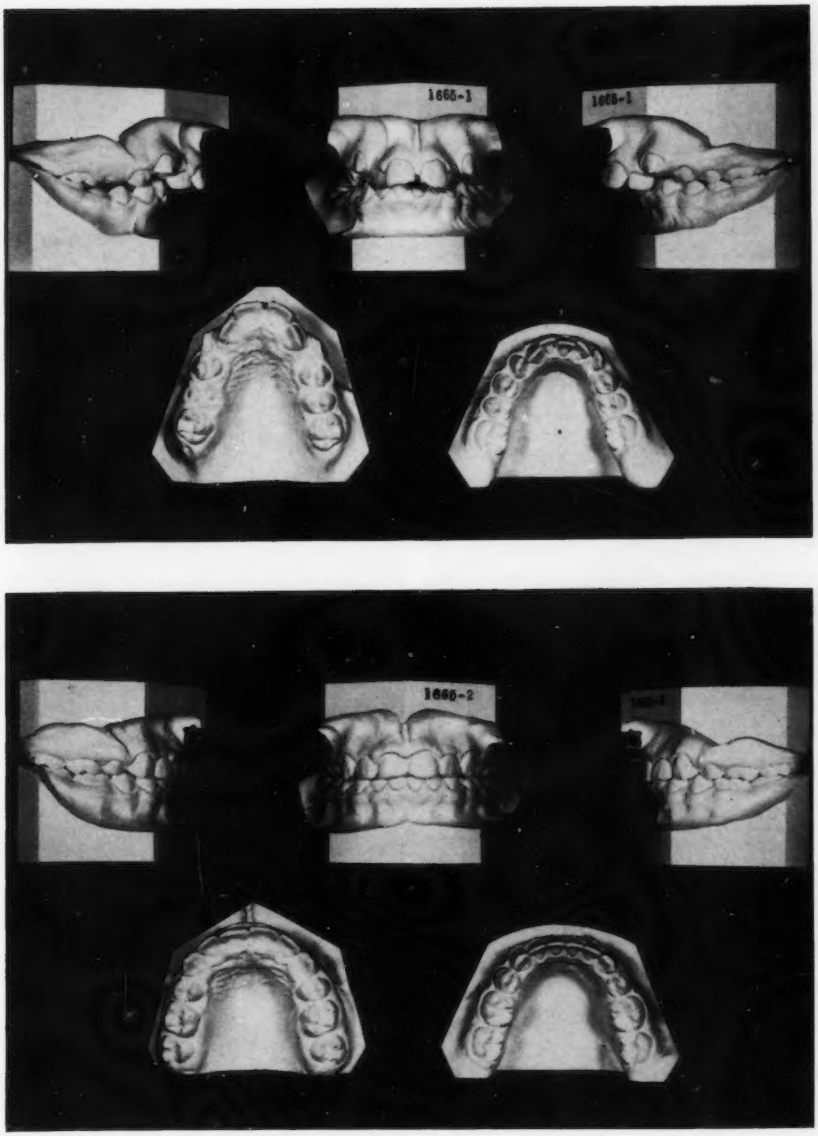

Fig. 7 Models of C. R. before and after treatment.

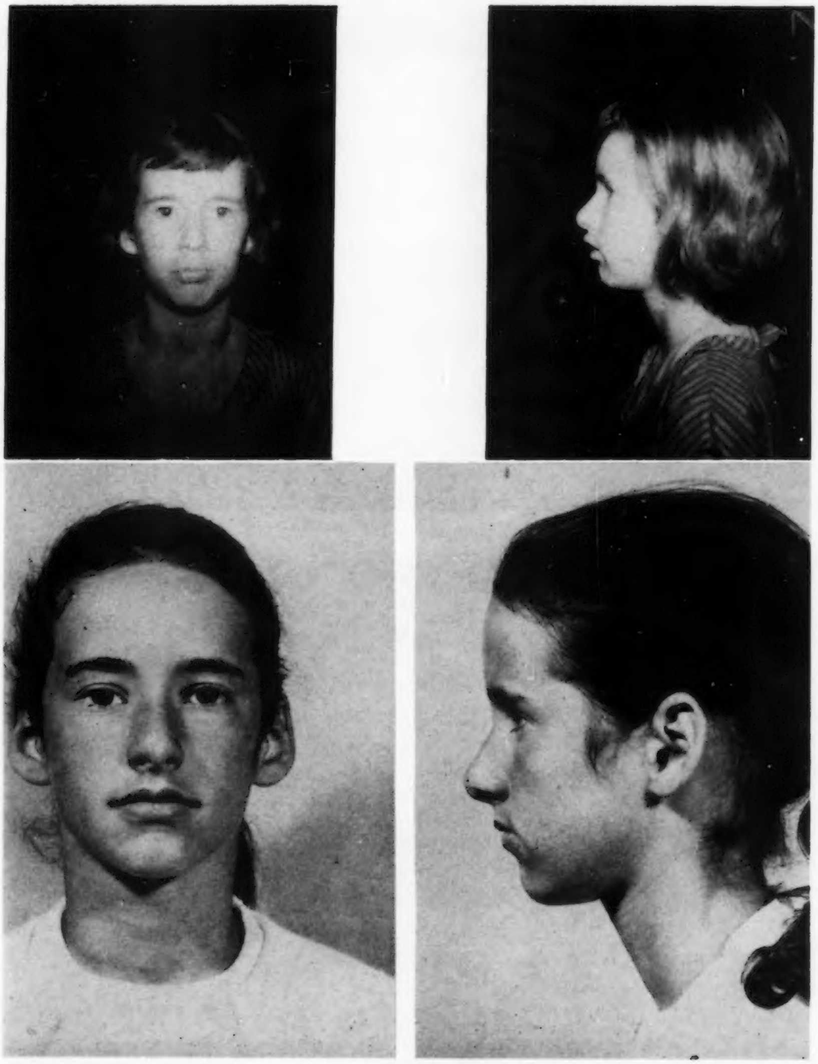

Fig. 8 Photographs of C. R. before and after treatment.

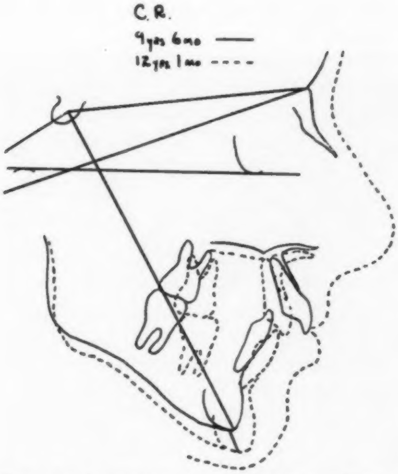

Fig. 9 Composite tracings from Downs analysis of C. R.

She had a 5 degree angle of convexity, a —7 degree AB plane, and an interincisal angle of 125 degrees. The maxillary incisors were 13 millimeters to the AP plane and the FMIA was 61 degrees.

She had been a persistent thumb sucker which contributed to the degree of malocclusion and disturbance in facial features.

In spite of the fact that the permanent dentition was completed and she was ready for treatment at such an early age, it did not seem conceivable that future growth could accommodate the degree of movement that would be required to occlude such a case. The maxillary first bicuspids and mandibular second bicuspids were extracted.

Spaces were closed in the mandibular arch first. When ideal arch alignment was completed, this arch was used as an anchorage unit, and intermaxillary elastics were employed with closing loops to retract the maxillary anteriors. Active treatment was completed in twenty-three months.

The changes in the cephalometric readings for the most part were favorable. The angle of convexity changed from 5 to 0 degrees, and the AB plane from —7 to —6 degrees. The change in the interincisal angle was due mostly to the labial tipping of the mandibular incisors. The maxillary incisors maintained their original inclination and have changed from 13 to 5 millimeters in relation to the AP plane.

TABLE III

C. R.	9 years 6 months	12 years 1 month
Facial Pl.	80	81
Convexity	5	0
A-B Pl.	—7	—6
Mand. Pl.	31	33
Y Axis	61	62
Occlusal Pl.	9	11
Interincisal	125	130
$\overline{1}$ to Occ. Pl.	21	22
$\overline{1}$ to Mand. Pl.	—3	1
$\underline{1}$ to A-P Pl. (mm)	13	5
FMIA	61	56

There has been a reasonable amount of facial growth during the two year treatment period. Appositional growth was quite pronounced at pogonion.

While the mechanics used in treating were the same as those employed in similar cases which have exhibited less ideal tooth movements, it is interesting to evaluate why this happens. Longer treatment time and an excellent growth response seem to be the most likely factors responsible for the change.

A current method of demonstrating orthodontic changes has been to relate such movements to the front of the face by transferring the original Frankfort and NP planes to the posttreatment tracing. This has been done for this case in Figure 10. This gives the impression that the maxillary incisors and point A have been moved lingually to an

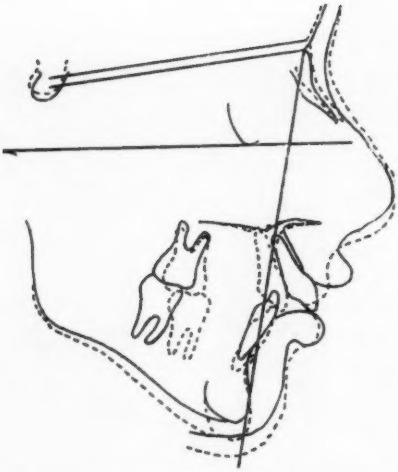

Fig. 10 Composite tracing of C. R. registered on the original Frankfort and NP plane.

extreme degree. The superimposition made on the contour of the maxilla in Figure 11 gives a more accurate indication of tooth movement than superimposing on the original NP as in Figure 10.

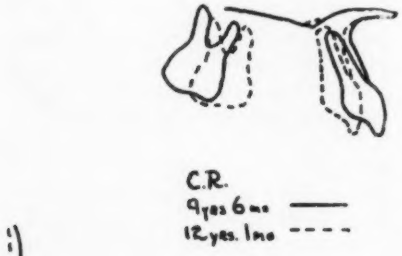

Fig. 11 Maxillary and mandibular composite tracings of C. R.

If, as some have recommended, the mandible is superimposed on pogonion as in Figure 11, it indicates a lingual movement of the mandibular incisors and alveolar process. This is an erroneous impression caused by the growth which has taken place at pogonion.

Case R.B. was a boy ten years of age with a Class II, Division 1 malocclusion. There was an extreme discrepancy in the incisor area with crowding of the mandibular incisors. The Downs analysis indicated structural relations approximating the mean except for the slightly high mandibular plane of 28 degrees. The interincisal angle was 123 degrees and the maxillary incisors were 9 millimeters to the AP plane. The denture was very prominent in the face which made it difficult to close the lips.

He was still sucking the thumb some at the beginning of treatment.

There was no hesitation in recommending the extraction of the maxillary first biscuspids and the mandibular second bicuspids. Treatment was carried out for this case the same as for the preceding one. The mandibular arch was closed first and used as anchorage for retracting the maxillary anterior teeth with intermaxillary elastics. Active treatment was completed in seventeen months.

While the changes in structural relations were not extreme, they were all adverse. The angle of convexity, the AB plane, the mandibular plane, the Y axis, and occlusal plane all changed unfavorably. There was practically no mandibular growth. While the maxillary incisors were changed from 9 to 0 millimeters to the AP plane, this was mostly a tipping movement. As unfavorable as it may be to have the mandibular incisors tip 5 degrees to the

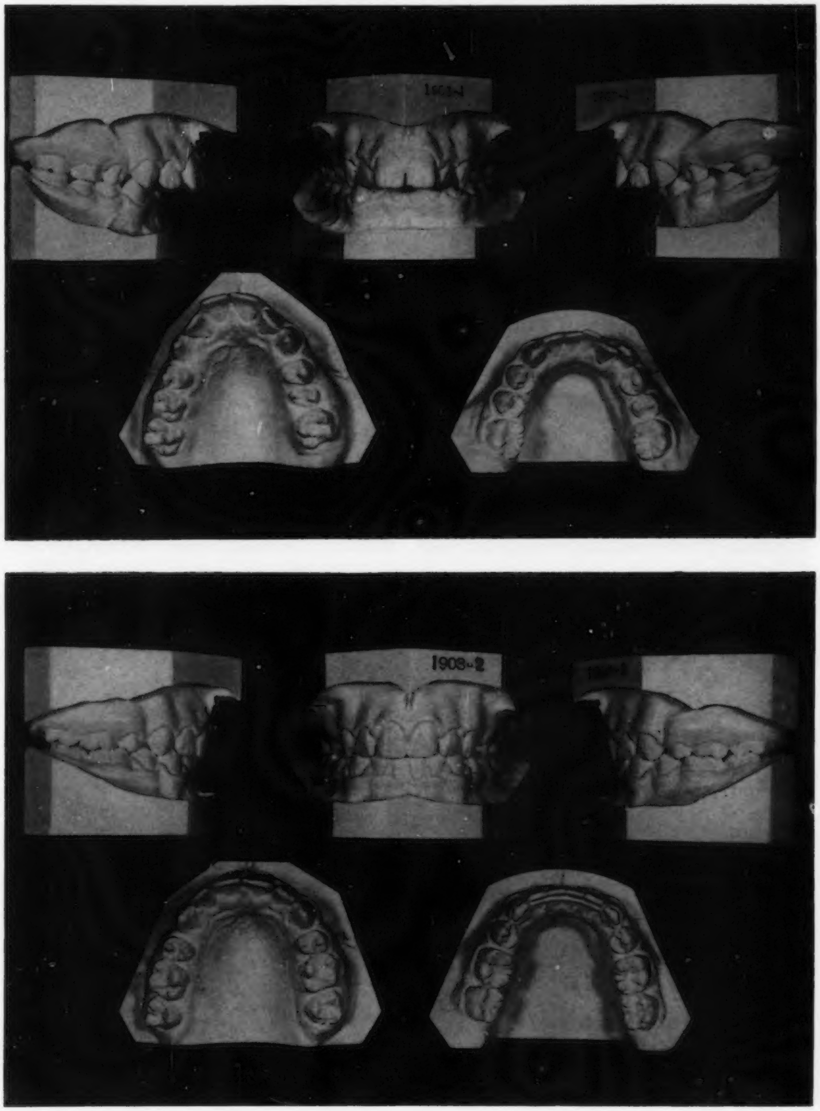

Fig. 12 Models of R. B. before and after treatment.

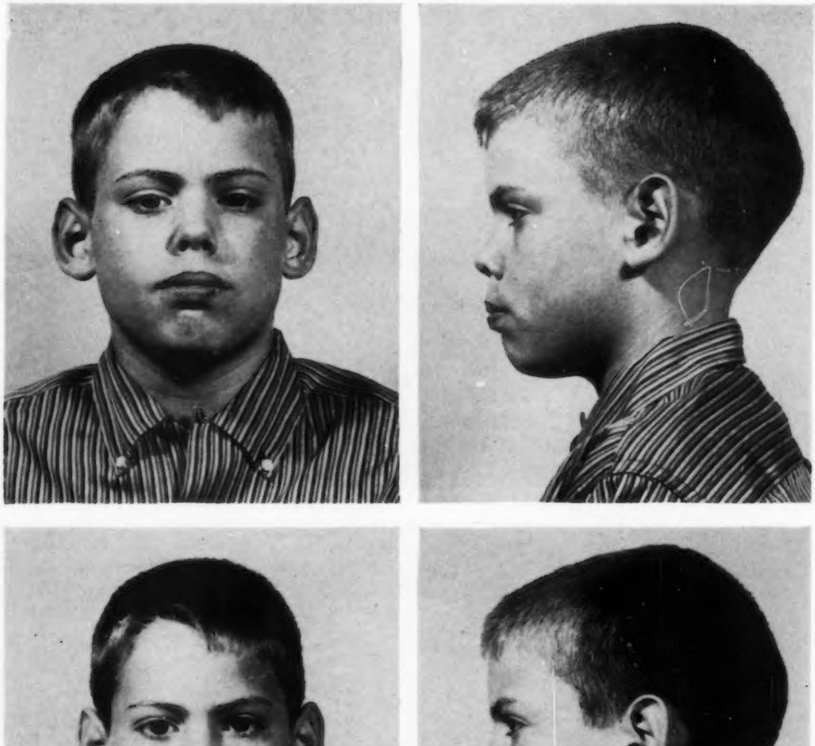

Fig. 13 Photographs of R. B. before and after treatment.

labial, if this had not occurred, the maxillary incisor position would have been worse, unless by extreme mechanics it would have been possible to get more bodily movement.

The appearance of the face improved considerably. The change in incisor position alone could be responsible for this. The patient was still below twelve years of age when treatment was completed and it is to be hoped that future growth may improve the relations which now exist.

It is logical to ask why this case responded so differently from the preceding one. Failure to use mechanics in the same way could be partly responsible. I believe, however, that the nature of growth has influenced the effect of appliance therapy to a large degree.

Dental relations are not static. Class I occlusions, whether treated or untreated, undoubtedly remain much more constant in their relation to the face and in axial tooth positions than do the other classes. Exaggerated tooth movements attempted in cases with bone and soft tissue discrepancy are difficult to obtain. They may result in damage to bone and root tissue and there is frequently a tendency for teeth to revert to their original position and axial alignment.

As discouraging as this may sound, it is not all so futile. Failure to obtain what is considered to be ideal tooth inclinations in treatment may be compensated for by posttreatment growth of the face and subsequent favorable dental adjustments. It is important to have patient cooperation during this period so that, if indicated, further guidance and retention of the denture may permit the forces of growth and function to act as favorably as possible.

The basis for establishing normal standards has been to use the measurements found in the esthetically pleasing, slightly convex type of face. The face which Tweed has used has a slight mental prominence and a denture which would be considered by many to be slightly recessive.

One can not argue to any degree about the esthetics of such a face, nor about the stability of the denture. I am sure we would be very happy if we

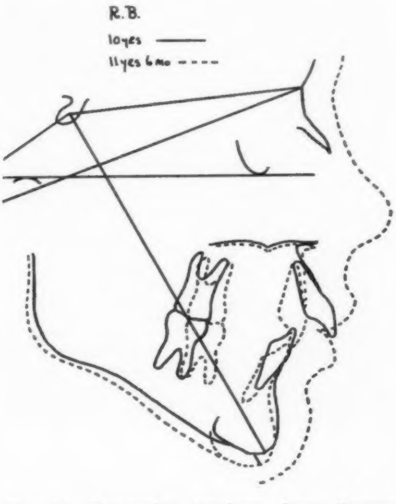

Fig. 14 Composite tracings from Downs analysis of R. B.

TABLE IV

R. B.	10 years	11 years 6 months
Facial Pl.	86	85
Convexity	3	6
A-B Pl.	—5	—9
Mand. Pl.	28	32
Y Axis	60	62
Occlusal Pl.	8	16
Interincisal	123	146
$\overline{1}$ to Occ. Pl.	23	20
$\overline{1}$ to Mand. Pl.	1	6
$\underline{1}$ to A-P Pl. (mm)	9	0
FMIA	60	53

could find such facial and dental relations requiring even some degree of treatment. However, a large percentage of cases that ask for treatment have varying degrees of bone discrepancy and inadequacy, coupled with tongue and labial and buccal musculature imbalance. A serious attempt to make all such relations conform to this assumed beautiful ideal standard is bound to result in injuries to bone and root structure, and in future disappointment resulting from instability.

Much time has been spent in examining the normal and the ideal both in untreated and treated cases. A vision of the ideal gives us a sense of direction and a goal toward which we aim in treatment. The beautiful stable result gives us encouragement and an opportunity to bolster any personal ego we may have. However, now that we recognize the ideal and are familiar with the measurements of such a face, I think we could benefit by spending some time re-examining the relations in faces which are not so ideal.

The records which I have examined indicate a strong tendency for incisor axial inclinations to vary according to the mesial distal relation of the maxilla to the mandible. The following four untreated adult cases have functionally good occlusions, but exhibit a wide range of variability, as do the faces.

The superimposition of lateral cephalometric tracings provides a graphic way of demonstrating the variations in the facial patterns and the way in which the denture in each case fits the pattern. It is my impression that all too frequently when we treat such tooth to bone relations and attempt to make the angles conform rigidly to our concept of the ideal, we ignore tooth to bone and soft tissue relations that have been stable and to which teeth will return if they have been disturbed excessively.

Case J.I. is thirty-two years of age with an excellent dental occlusion, good esthetics and structural relations. The measurements conform to the Downs normal range. The maxilla is posterior in its relation to the mandible with the resulting —9 degree angle of convexity and 1 degree AB plane. A 24 degree mandibular plane angle is associated with the mandibular incisors at 85 degrees to the mandibular plane and an FMIA of 71 degrees. This is a striking example of lingually-inclined mandi-

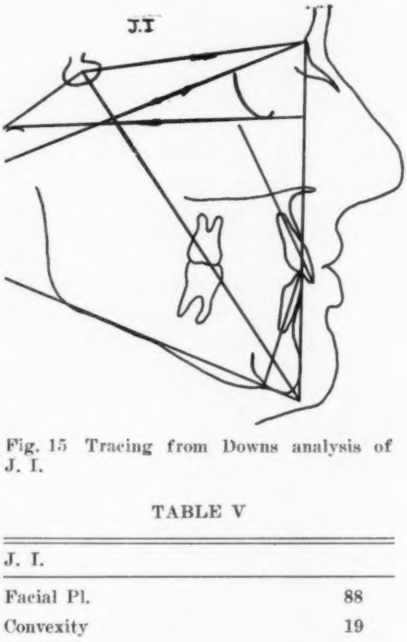

Fig. 15 Tracing from Downs analysis of J. I.

TABLE V

J. I.	
Facial Pl.	88
Convexity	19
A-B Pl.	1
Mand. Pl.	24
Y Axis	58
Occlusal Pl.	11
Interincisal	139
$\overline{1}$ to Occ. Pl.	8
$\overline{1}$ to Mand. Pl.	—5
$\underline{1}$ to A-P Pl. (mm)	5
FMIA	71

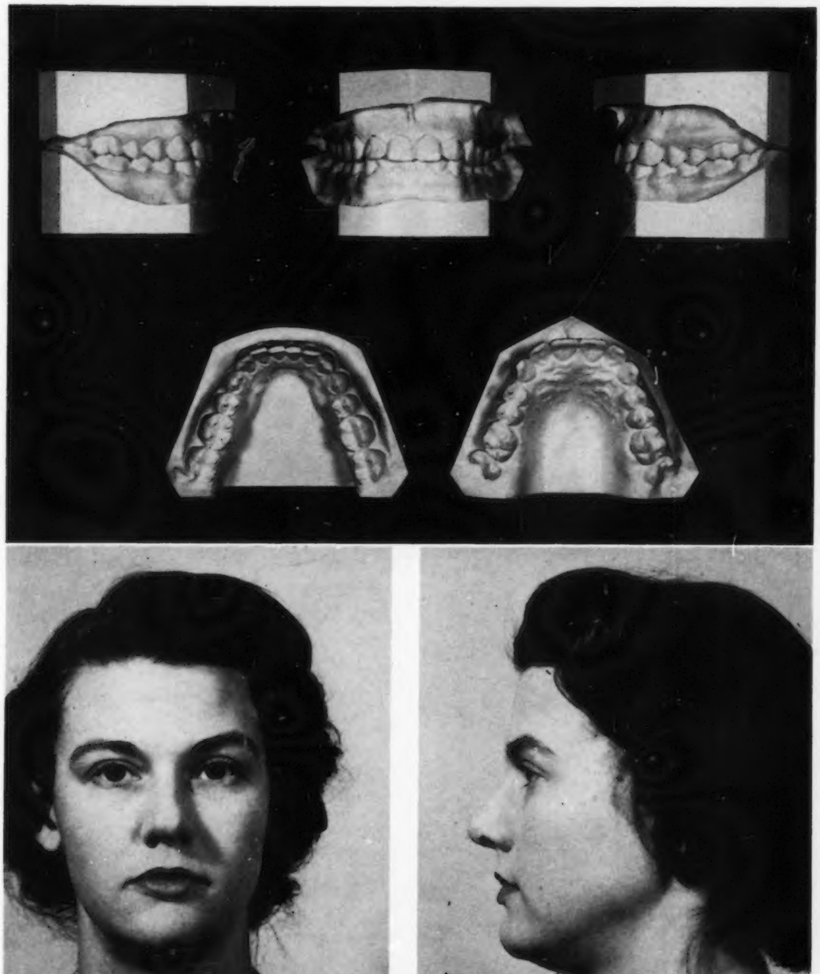

Fig. 16 Models and photographs of J. I.

bular incisors fitting harmoniously into a pattern of a posteriorly located maxilla.

The Frankfort plane has been considered to be reasonably normal in its location with an angle of 6 degrees to the SN plane. It will be used as a standard for comparing some of the succeeding cases.

Certainly no one would ever be criticized if they treated to the measurements which exist in this case. If the orthodontist was not most sensitive to the structural relations, he would probably leave the mandibular incisors tipped more to the labial, whether done intentionally, or by lack of care in archwire adjustment. Such movements could be traumatizing and also require additional posttreatment adjustment by natural forces.

Case B.D. is twenty-six years of age with a functionally good occlusion. There have been no third molars.

There is a 14 degree angle of convexity, —8 degree AB plane, 33 degree mandibular plane and FMIA of 52 degrees. The Bolton triangle is almost

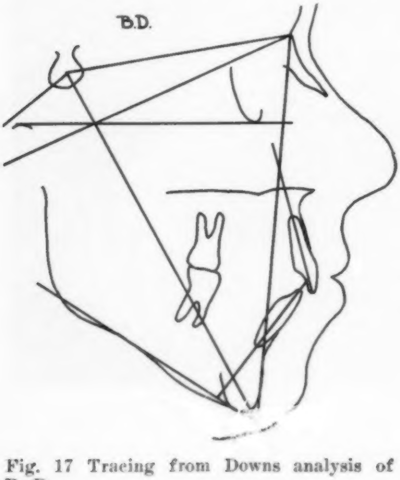

Fig. 17 Tracing from Downs analysis of B. D.

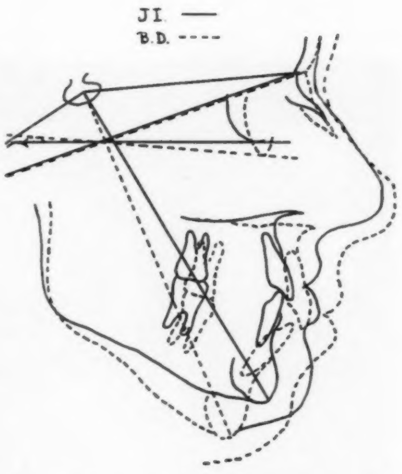

Fig. 18 Composite tracing of B. D. and J. I.

the same size as in J.I. The anterior end of the Frankfort plane is 5 degrees lower than in J.I., which causes measurements to Frankfort to be 5 degrees more favorable than they should be for conveying the same impression of relations as in J.I.

A composite of the lateral tracings of these two cases superimposed on the Bolton triangles shows the second case farther forward at nasion, maxilla, the

TABLE VI

B. D.	
Facial Pl.	85
Convexity	14
A-B Pl.	—8
Mand. Pl.	33
Y Axis	62
Occlusal Pl.	12
Interincisal	129
$\overline{1}$ to Occ. Pl.	25
$\overline{1}$ to Mand. Pl.	5
1 to A-P Pl. (mm)	10
FMIA	52

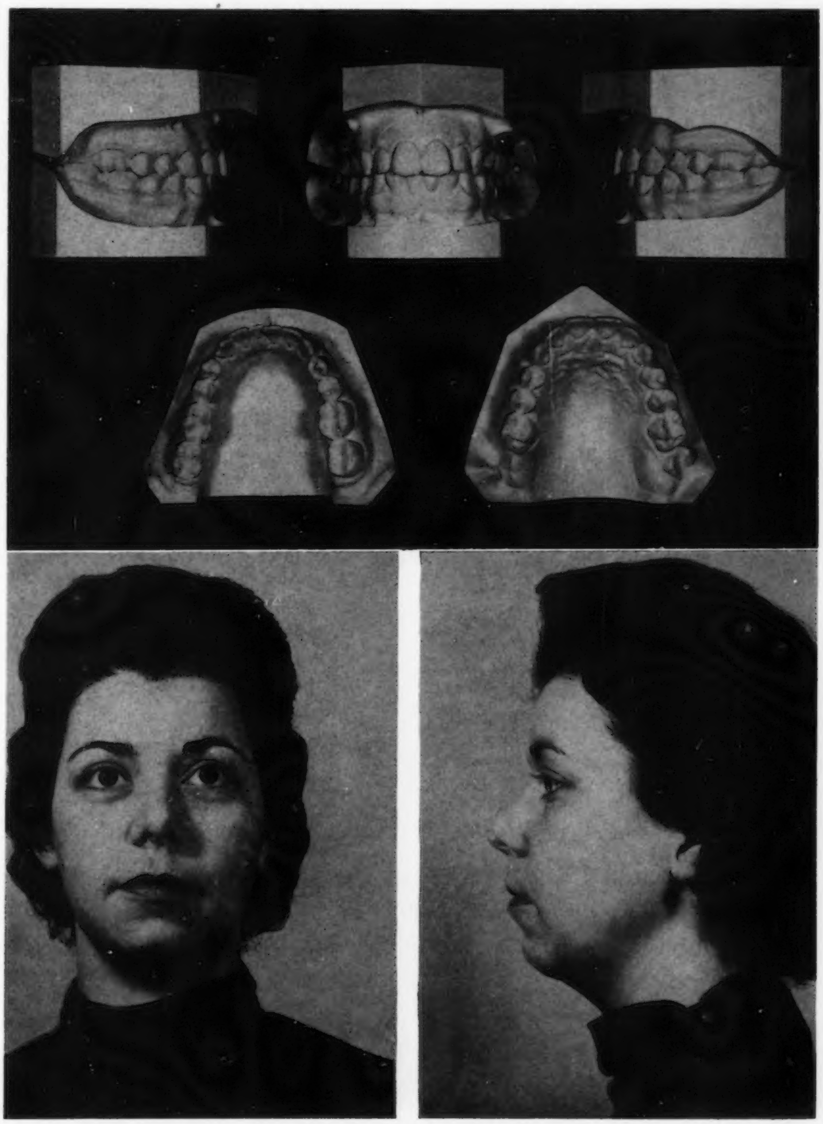

Fig. 19 Models and photographs of B. D.

nose and lips, with a posterior position of pogonion and a steep mandibular plane. There is a conspicuous tendency for the teeth in each case to fit the structures of the face.

This patient is not at all concerned about the relations of her denture and, if she were, it would not be wise to attempt changing it with the possibility of damage to the health and function which exist.

If malocclusion were present in such a structural relation, I believe it would be unwise in treatment to place the incisors in an exaggerated lingually-inclined position since they would not fit the components which exist in the remainder of the facial complex.

The positioning of the mandibular incisors lingually would require lingual movement of the maxillary incisors with very extensive lingual root movement. While it is possible to do this, the logic of such movement is debatable. The denture is already in good alignment with good tissues and function. Lingual positioning of the teeth and resulting change of contour of the lips may help

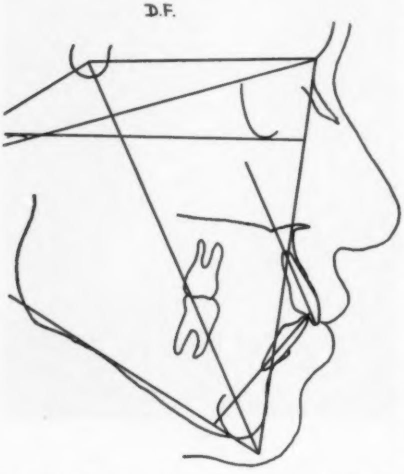

Fig. 20 Tracing from Downs analysis of D. F.

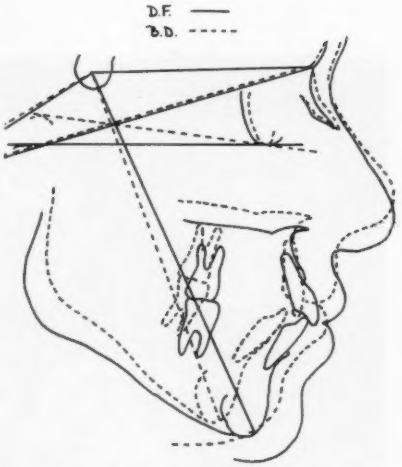

Fig. 21 Composite tracing of B. D. and D. F.

the contour of the tissues of the chin, but will exaggerate the contour of the nose. In all probability the effect of pattern and muscle balance in the posttreatment period would cause the teeth to approach their original relations.

Case D.F. is forty-three years of age with a functionally good occlusion. While the denture appears protrusive with a procumbency of both maxillary

TABLE VII

D. F.	
Facial Pl.	84
Convexity	1
A-B Pl.	—1
Mand. Pl.	31
Y Axis	65
Occlusal Pl.	11
Interincisal	117
$\overline{1}$ to Occ. Pl.	28
$\overline{1}$ to Mand. Pl.	6
$\underline{1}$ to A-P Pl. (mm)	12
FMIA	52

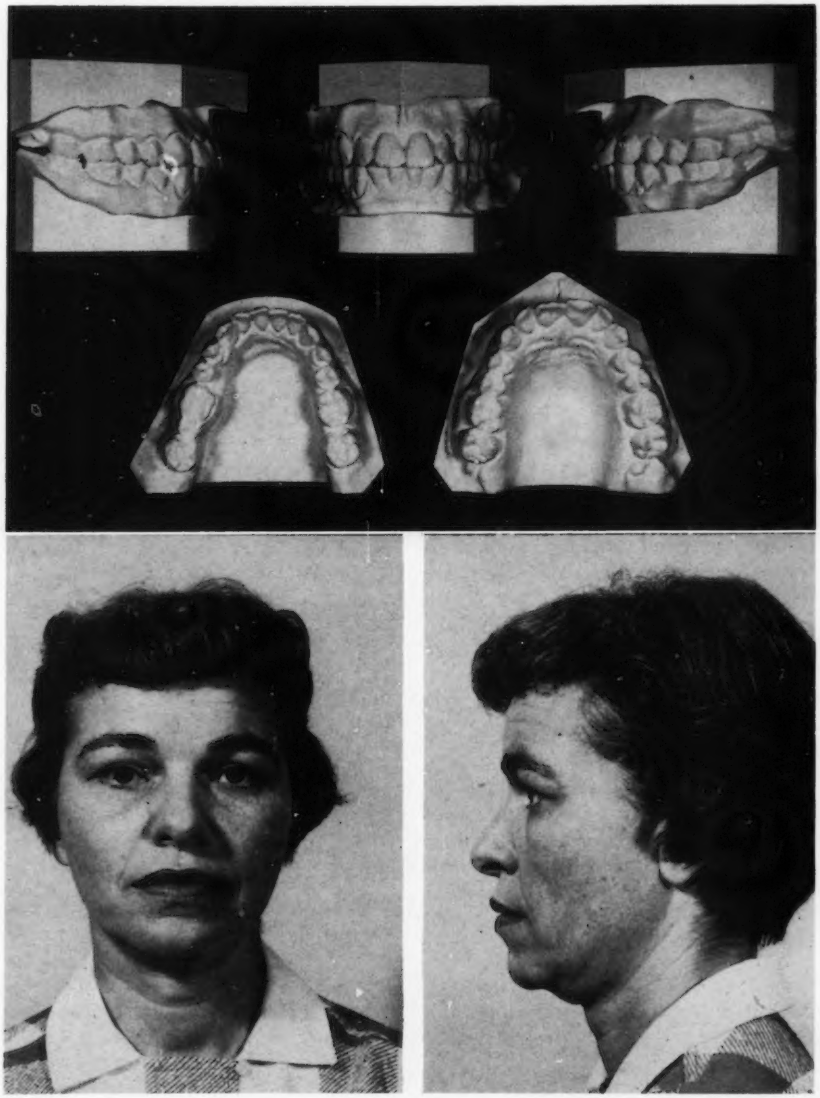

Fig. 22 Models and photographs of D. F.

and mandibular incisors, the muscles of the face are relaxed and function well.

The facial balance and tissue relations are better in this case than in the previous one, B.D. The increased procumbency of the maxillary incisors would seem to be an adjustment to the more anteriorly placed mandible and straight face with a one degree angle of convexity.

The 8 degree difference in the relation of the Frankfort planes of the two cases may appear to be a part of a total pattern, but should be considered in interp.eting angles related to Frankfort. D.F., with the straight face and anteriorly located pogonion, actually has the less favorable 65 degree Y axis reading. While they both have a 52 degree FMIA, their mandibular incisors are not located the same in the face.

The superimposition of the tracings of these two cases provides a good illustration of the adaptation of the denture to the structures of the face. The maxillary incisors in particular are inclined forward in the st.aight type of face having good mandibular development. They are inclined lingually in the face with the recessive mandible and the steep mandibular plane.

If the axial inclinations of the incisors fit the structures of the face with any degree of balance as they seem to in these two cases, then orthodontic treatment which changes these angular relations also disturbs balance and function.

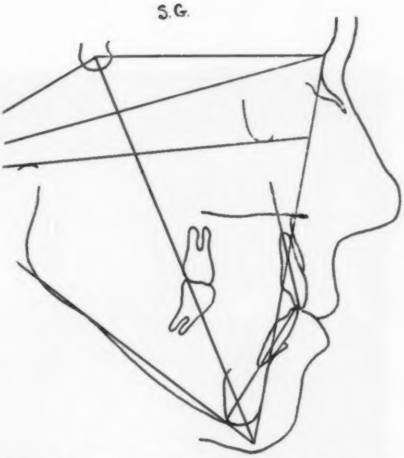

Fig. 23 Tracings from Downs analysis of S. G.

TABLE VIII

S. G.	
Facial Pl.	74
Convexity	—3
A-B Pl.	1
Mand. Pl.	43
Y Axis	74
Occlusal Pl.	22
Interincisal	134
$\overline{1}$ to Occ. Pl.	17
$\overline{1}$ to Mand. Pl.	—5
$\underline{1}$ to A-P. Pl.	8
FMIA	52

Case S.G. is forty-seven years of age. Although she has had some posterior teeth extracted, the occlusion of the rest of the teeth and the incisor position is very acceptable. The face with its —3 degree angle of convexity is pleasing in its appearance.

The facial dimensions are similar in size to the first case, J. I., which had very ideal tooth and bone relations and supposedly a normally located Frankfort. A superimposition of her tracing on that of J.I. shows a face longer in vertical dimension with a steeper mandibular plane, and a more retrusive position of pogonion. The change in mandibular incisor position fits her pattern very well. Porion, being located very low in the face, causes a 10 degree difference in the angle of Frankfort. This is responsible for the ex-

Fig. 24 Models and photographs of S. G.

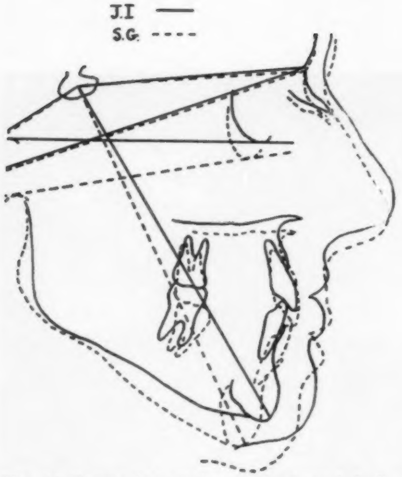

Fig. 25 Composite tracing of S. G. and J. I.

treme discrepancy in all the measurements related to Frankfort. Of particular interest is the FMIA of 52 degrees in a face with quite acceptable facial and denture relations.

This patient has never considered that she had any need for orthodontic treatment and of course has never had any. This is no doubt fortunate for her sake. With the Frankfort plane so situated, had there been some excuse for treatment, a present day philosophy would indicate the necessity for establishing an FMIA of 65 degrees which no doubt would be highly damaging to tissues and also unstable.

The mandibular incisors, according to some present day standards, are too far forward in relation to bone structure. Certainly many would criticize their position if they had been so treated. However, this case, even with the posterior extractions, has had many years of good function and healthy tissues. It would be my guess that many treated cases at forty-seven years of age will never have as good function or as healthy tissues as are present in this case.

Discussion

1. The results of orthodontic therapy are more favorable when they are complemented by growth processes.
2. The variations of growth in the cases which were treated indicate that appliance therapy has only a small effect upon growth tendencies.
3. Tooth positions and inclinations are affected quite extensively by the distribution and amount of growth. Cephalometric records taken at frequent intervals may be used to determine when it is necessary to alter the mechanics to resist unfavorable effects of growth.
4. Serial evaluations of tooth movements during treatment should differentiate the changes instituted by therapy from those that are the result of growth.
5. Variations in the position of Frankfort make it unreliable as a plane to which other structures can be related except in serial studies.
6. Infinite variations in face and tooth relations make rigid standardizations in orthodontic goals inconceivable. Beauty and harmony are the product of all the structures of the face. Since the denture area is the only part readily alterable, any changes made there must complement as much as possible the other components of the face.
7. Variations in structural relations make it difficult to consistently move teeth to preconceived positions of normalcy. The forces dictated by growth, structural relations and muscle function will ultimately alter the results in the postretention period. This is consistent with the adjustment of

tooth position according to structural relation observed in the untreated adult cases.

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Discussion

Dr. C. F. Wright

We are indebted to Dr. Buchner for a very fine and timely paper and I am happy to have this opportunity to discuss it for he has mentioned some points which I have been discussing with some of you for a long time; this gives me an opportunity to discuss these factors with all of you.

I can agree that the present day orthodontist is better equipped to render a better diagnosis and a better service than ever before and, in general, I think that he is doing just that. When I compare my own results and yours with results of thirty years ago, there can be no doubt about it.

However, unlike Dr. Buchner who is amused at the slide rule diagnostician, I am concerned about him, and the influence he is having upon the thinking of the profession. I am concerned because such diagnostic methods are contemptuous of the biologic aspects of the problem. The slide rule diagnosis tells us nothing of the biologic processes involved in the development of normal occlusion, nothing of the teeth themselves, their supporting structures or of their function. Perhaps, most important of all, it makes no allowances for time. The slide rule diagnosis, like the diagnosis made from a set of occluded plaster models, can be very misleading and can create problems where no problems exist for both represent but an instant of time.

I think the essayist demonstrated this point very clearly. In the first case shown the results were functionally and esthetically acceptable for this individual, yet some of the slide rule readings are far outside of the accepted cephalometric standards and the results are worse by those standards than they were originally. The point here is that the natural biologic and functional forces working with time ignored any preconceived standards.

The second case is an excellent example of how a static model or slide rule diagnosis can betray one. I should like to emphasize how one must project what we have learned about growth and development and the working of time into analysis and treatment planning. I think we would all agree that this individual has a beautifully proportioned face, one that belies the malocclusion present, and one we do not wish to change except to keep it progressing forward with the downward and forward growth changes of basal structures that we expect to occur. From the models we discover that on the left side there is a perfectly normal relationship of teeth to each other in the same arch and equally good relations of the teeth of one arch to those in the opposing arch and all in fine relation to their respective jaws. Turning now to the right side, there is the same good relationship of teeth to each other in the same arch but a Class II relation of the arches as indicated by the teeth in this occluded model. This latter relationship could be misleading. There could be present a right mandibular deflection arising from the retruded maxillary incisors. We can be quite certain of this for both arches are

symmetrical, yet there is an inharmony of the midlines to the extent of a complete tooth. Often, a functional analysis will verify this, but not always, for the muscles may have been conditioned to this deflection. In treatment the occlusal interference offered by the retruded maxillary incisors must be relieved first to permit restoration of the disturbed balance of the muscles of mastication. When this is done, many times there is a spontaneous correction of the Class II relation and the remainder of treatment becomes routine. This biologic analysis and timed treatment permits the forward movement of the denture to keep pace with the downward and forward growth of basal structures and avoids embarrassing results such as have been experienced in this case.

I am sure Dr. Buchner will agree for in his remarks he said, "The photographs taken at the conclusion of treatment showed disappointing results. The lovely, straight profile and excellent balance in the original have changed to essentially a concave profile in spite of all the precaution taken in treatment to avoid such a result. A study of the composite tracing will show in some degree why this happened. While the lip area remained in essentially the same position, there has been considerable growth of the nose and mandible. Some growth has occurred at gonion and there is a great amount of appositional growth at pogonion." Here is cephalometric evidence that we may expect growth beyond thirteen years of age in girls. These growth changes must be taken into account in diagnosis and treatment planning.

It may be disturbing to some that they can no longer put all of their problems into a single worry, the worry of creating a double protrusion. It is high time to begin worrying just as much about creating a *double retrusion*. These cases, together with the other cases he has shown, offer further evidence that the slide rule or the static model diagnosis alone cannot be depended upon.

It is my opinion that orthodontics has progressed far enough into the future so that it can look back with a clear vision that characterizes hindsight and appraise with a critical eye where we stand. Since cephalometric studies were introduced into orthodontics some thirty years ago, perhaps no research weapon has ever been used with greater concentration by a profession. Used in the hope of finding not only when, where, in what places and in what directions the dentocranial complex grows but also, in the hope of finding some pattern, or averages or range of normals to which a patient could be satisfactorily treated. While this research has given the answers to many of these questions, the time has come that a review of this statistical knowledge be made and its often detrimental effect on diagnosis and treatment planning be brought to light as has been done by Dr. Buchner in this paper.

I believe that our profession can be justly accused of using this body of statistical knowledge compiled by cephalometric studies as a drunk uses a lamp post. An inebriate does not use a lamp post for light but for support. He has distorted its intended purpose. In the same way the orthodontist has distorted statistical knowledge by using it incorrectly for diagnosis, rather than as a research tool. As a tool, it sheds light on our problems, but, as an inflexible diagnostic entity, its usefulness is sadly limited.

Thus, we can see that cephalometrics is primarily a research instrument which has been invaluable in pushing forward our knowledge of growth and development. To the clinician it reveals the changes that have occurred during treatment and retention periods.

It has become increasingly evident that the diagnostician should consult the patient as well as the "wiggle". He should correlate cephalometric data with the biological changes that may be expected to occur, during and after treatment, as a result of orthodontic management and of the maturing of the patient.

As we learn to implement our mechanical skills and statistical findings with increased biologic awareness, the time may not be too distant when we can attain a synthesis of these elements. This would, indeed, be progress.

Discussion Of The Newer Trends And Techniques

Robert H. W. Strang, M.D., D.D.S.

Bridgeport, Connecticut

So many men have approached me with the question, "What do you think of this light wire technique?", that I welcome the opportunity to discuss this subject.

Primarily I am placing myself in the same situation as I believe the younger men in our specialty now find themselves. I am certain that this wave of interest and enthusiasm which has swept thoughout our ranks has coincidentally brought marked confusion to these recent graduates and the question arises in their minds whether or not to discard the training that they have just received and take up this new technique. Also, will they be back numbers if they do not accept this procedure? Consequently I believe that an analysis of this situation by an individual who has been through several of these crises may be of help to them.

Probably no one here has had to change more procedures in technique than the essayist. An analysis of why these changes have been made has an important bearing on the present situation. The first shift came with the acceptance of the pin and tube appliance over the old plain .030 archwire, the so-called "E" arch. This change was made because it could do something that the plain archwire could not do, namely, move the roots of teeth instead of just tipping tooth crowns. This indicated that it was a more efficient appliance.

Then came the ribbon archwire appliance, the first of the bracket mechanisms. Again, this could accomplish root movements by a less complicated technique than the pin and tube. It not only had control over root movement but also could rotate teeth. It no longer fixed individual teeth to one location on the archwire but allowed them to shift from side to side when crowded. It also introduced the advantages of torque force for root movement and anchorage purposes. Furthermore, it was a one-piece archwire instead of being in three sections and permitted torque action on the anchor teeth. So it was adopted because it was a more efficient appliance than the pin and tube.

I would also bring to your mind that soon after the ribbon arch appliance was introduced another opportunity came to change mechanisms. This offering was the lingual arch appliance introduced by Dr. John Mershon and, as many of you know, accepted by a great number of specialists. This appliance was by-passed by your essayist because he believed it to be decidedly lacking in efficiency owing to the fact that it had no control over root positioning. My reaction to this appliance is expressed in a very positive manner in the Dental Cosmos, Vol. 64, 1922.

Finally came the edgewise archwire mechanism which offered still greater efficiency over the ribbon arch appliance in that it added root control over the premolar teeth both in buccolingual and mesiodistal directions. This was accepted as a successor to the ribbon arch.

Presented before the Strang-Tweed Study Groups, New York, December, 1960.

Following the introduction of the edgewise arch came the twin arch appliance, a much better appliance than the lingual arch mechanism and a popular one even today. However, I believe all will agree that to change from the edgewise to the twin arch would be giving up certain advantages in root control.

Note that each successive mechanism that was accepted had the possibility and means of producing better results with an added incentive of obtaining more permanent stability of the product of treatment than did the preceding appliance. Furthermore much of the technique of the former device could be transferred to the new one. With the acceptance of the edgewise arch appliance, modifications for tooth movement could be accurately plotted from a governing chart. One was finally in possession of a precision mechanism which was under the perfect control of the experienced operator.

We are now confronted with the problem of accepting or rejecting another device for treatment procedures. The first question to answer is, "Will this mechanism enable us to produce better results than the one we are now using and more permanent stability of the finished product?"

In the hands of Dr. Begg, unquestionably it has produced just as fine results as the edgewise appliance and in a comparatively short period of treatment. His results equal those found in any completed cases that I have ever seen. I have only the greatest praise for his work and I classify him as one of the outstanding orthodontists in the world today. But Dr. Begg has had twenty years of experience with this device and he and his associate, Dr. Simms, are the only ones whom I know who have carried their cases through to completion with such excellent results using only this mechanism from start to finish.

When the opportunity came to take Dr. Kesling's course at a time when Dr. Begg would be present, I decided to apply for membership and was accepted. I appreciated this privilege as I did not feel that I had any right to discuss the merits of this mechanism unless I had received all the instruction available. I am very thankful that I attended the session and can honestly say that I profited greatly by doing so.

I was made fully aware of the fact that these light wires, of high tension quality, will move tooth crowns quickly and efficiently. I learned that all treatment was based upon tooth tipping, first the crowns and then the roots, that molar anchorage depended upon using a force so light that multirooted teeth would not move to any great extent but single-rooted teeth, on the other hand, would receive sufficient force to move. All of this was rational and acceptable.

However, the reverse procedure of stabilizing the single-rooted teeth by a force sufficient to move the multirooted teeth was a concept that was more difficult to accept. Being purely biologic in its analysis, and hence depending upon stasis in tissue reaction because of diminished blood supply, and realizing that reaction in tissues of individuals was not open to standardization but was quite a personal problem, this seemed quite a trial and error proposition. It might be possible to arrive at the proper degree of force application if one was to see his patients every day but to turn on the power and send the patient away for several weeks was purely guesswork.

Then came the stage in treatment when crown tipping had to be followed by root tipping. This was to be accomplished by an auxiliary light round archwire in which obliquely directed vertical spring loops were incorporated and

bent gingivally to contact the incisor crowns at their cervical edge. This was pinned to the band slot on the gingival side of the primary archwire. Its ends did not pass through the molar tubes but were caught over the primary archwire.

This particular treatment procedure, in my mind, is the weak link in the Begg appliance. Having been the individual who introduced the vertical spring loop in the edgewise appliance technique, a suggestion which brought forth bitter criticism when presented in 1931, I was fully aware of the fact that vertical spring loops were quite difficult to control, as far as their specific force of activity was concerned, even in an edgewise archwire. However, in the edgewise appliance one did have control of the top of the loop in a labiolingual and buccolingual plane by virtue of the precision adjustment of the archwire in the bracket slot. In this round light wire adjustment, with absolutely no control in these planes at the points of fixation to the bracket, how could precision adjustments possibly be incorporated in this mechanism?

Examination of Dr. Begg's cases showed very definitely that he had controlled the action of these vertical spring loops sufficiently well to obtain the desired root movements. This demonstrated that it could be done. It is for this perfection of technique that I again proclaim Dr. Begg to be one of the outstanding orthodontists in the world today.

However, Dr. Begg's ability to overcome this unquestionably inefficient technical method of producing desirable root movements, so essential in obtaining a stable result in treated cases, does not eliminate the fact that there is a very undesirable weak link in the chain of efficiency of this light wire technique. This was further emphasized by the fact that Dr. Kesling gave evidence of recognizing this weak link in all cases that he exhibited at this course. Dr. Kesling's cases were not carried to completion by this looped auxiliary root-moving archwire but, at a certain stage of treatment, the Begg appliance was discarded and a positioner was given to the patient for the finishing adjustments of root and crown relationship.

Now Dr. Kesling is an expert orthodontist and one of the finest operators that we have in the specialty. If he does not see fit to put the finishing touches in his cases with the third stage of the Begg technique, certainly, less experienced young men cannot do it and many experienced operators will also be unsuccessful in its use.

I am convinced that this light, resilient wire can be used to advantage by an experienced operator in certain stages of treatment. It unquestionably will move teeth very rapidly and with little discomfort to the patient. Consequently, for leveling in the horizontal plane, for rotating teeth, for opening and closing spaces and for opening the bite, it is extremely useful. But, as mentioned before, for root movement it requires a second auxiliary archwire. The technique associated with its application for root movement is exceedingly intricate and lacking in precision control.

Furthermore, note that I have said for an experienced operator to use. I am firmly convinced that unless the orthodontist is well-grounded in a technique such as is associated with the use of the edgewise arch mechanism, he is not qualified to treat cases with this appliance. The incorporation of modifications from the horizontal plane in the form of loops and hooks is not only difficult to make and properly locate, but also exceedingly hard to control in the vertical plane so as not to impinge on gingival or lip tissue. This

wire will twist in such an unpredictable manner when inserted in the brackets that it is quite impossible to foresee such deviations previous to its bracket fixation. Bending the loops after bracket engagement is very apt to modify or even destroy their previously planned action.

In Dr. Angle's teaching, simplicity of archwire design was emphasized. As previously stated, when I introduced the vertical spring loop in edgewise technique, I was vehemently and bitterly criticized until the accurate and safe technique associated with its use and coincidentally described with its introduction was understood and subsequently adopted. At the present time no such accurate technique for evolving archwire form, loop positioning and modification is available to the novice who wishes to try this light wire appliance. Hence one has a trial and error problem confronting him at the start. The experienced operator has a means at hand for correcting errors for he can always fall back on his edgewise appliance. Consequently, my advice to recent graduates of orthodontic courses and for less experienced operators is to first learn to use an efficient mechanism which has associated with it an accurate, available technique before attempting to treat any cases with this very complicated appliance. Above all else, do not let anyone make you believe you are a back number if you do not use Dr. Begg's technique. I can assure you that there are very few orthodontists in this country who can approach Dr. Begg's ability as an operator. His results are magnificent and spectacular. But remember he has spent many years with this appliance and was grounded in edgewise technique previous to its use. Most certainly he has taught us the efficiency of light wires in properly tempered form and I am sure that they can be used with advantage as previously mentioned.

I am deeply grateful to Drs. Begg and Kesling for teaching me the advantages gained by the use of this so-called differential force application. I am using it in all stages of treatment where I believe it is indicated. But, for the production of accurate and delicate root movements so essential for effecting permanent stability in a treated case, I still depend upon the edgewise arch appliance.

It is far from my intent to discourage any capable operator from accepting this appliance if he believes that it offers advantages over the one he is now using. If he can treat more patients in the same available time and give them equally satisfactory stabilized results, he is advancing the welfare of the specialty by more nearly meeting the demands of the public which are certainly on the increase. My concern is for the welfare of the less experienced operator who, I definitely believe, is not sufficiently prepared to use this intricate technique until he has acquired a sound foundation in edgewise appliance manipulation thoroughly tested by clinical application and backed up by creditable treatment results. He then has a means of correcting errors that may arise as a result of faulty adjustments of the appliance under discussion.

It having fallen my lot to be a director and teacher in a School of Dental Hygiene, there is another factor that quite naturally comes to my mind and hence I would like to mention it at this time as exceedingly detrimental to the use of these various forms of light wire technique now being advocated by various individuals. This is the great danger of injury to exposed enamel surfaces by accumulations of food debris that cannot possibly be removed by the most fastidious patient in the home care of oral structures.

Any loops that overlie or touch ex-

posed enamel surfaces are bound to be food catchers and retainers. Loops that overlie gingival tissues are very difficult to control in their relationship to these tissues as their activity dispenses itself. Hence impingement and embedment in these soft tissues does occur, even in the hands of the expert operators. The size and numbers of these massive loops advocated by certain technical procedures is astounding to behold. The trend of advocating simplicity in mechanisms has passed so far from the teaching of Dr. Angle as a fundamental concept that those of us who still believe that the protection of tooth structure and gingival tissues should be the subject of great concern by the orthodontist are exceedingly disturbed. For years the damage done to these tissues during the period of orthodontic treatment has justly been of great concern to the dentist and also to parents. It is my feeling that many of these present techniques of corrective procedures will aggravate this condition rather than alleviate it. This is not good to contemplate.

The one virtue that is accorded this light wire technique is the speed of accomplishing the end result. If tissue damage is sacrificed for this speed, then we are paying a very high price for the virtue.

114 *State St.*

The Interrelationships Among Height, Weight And Chronological, Dental And Skeletal Ages*

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Introduction

Orthodontics includes the study of the growth and development of the dentofacial complex particularly, and the growth and development of the body generally[16]. Over-all growth and development should be recognized as one of the most important factors in orthodontics.

The early prevention and interception of dentofacial deformities is dependent upon an accurate interpretation of the inherent facioskeletal pattern and the over-all growth and development.

Hereditary, functional, environmental, sexual, nutritional, and metabolic factors influence normal growth and development greatly. The proportional effects of each of the factors are not easily determined, but nevertheless, orthodontists should attempt to evaluate each patient in relation to these influences.

Physical growth and developmental manifestations provide useful criteria for orthodontic diagnostic evaluations. Orthodontists frequently utilize such physical characteristics as weight, height, skeletal maturation and dental development which are subjected to biometric tests and compared with standards based upon large groups of healthy subjects in order to evaluate the growth and maturational status of patients.

*Based on a thesis submitted to the Graduate Faculty in the School of Dentistry in partial fulfillment of the requirements for the degree of Master of Science, University of Pittsburgh, June, 1960.

In this study, the nature of the interrelationships among height, weight, and chronological age, dental and skeletal development was investigated. The purpose of this investigation was to point out the value of various physical indices of the over-all developmental status and the nature of the relationships among these indices.

The appearance and union of the different skeletal centers of ossification follow a fairly definite pattern and time schedule from birth to maturity. A roentgenographic study of these skeletal maturational processes provides a valuable criterion of the child's level of osseous maturation[13],[23]. The skeletal maturity of the individual is known as bone age or skeletal age. The carpal area provides a useful index of skeletal maturation and is frequently utilized because it is easily accessible and radiographs can be taken at a minimum of expense and time[12].

Suitable standards, such as those of Todd,[22] Flory,[4] Greulich and Pyle[8,9] are used to determine skeletal age when the x-rays are evaluated.

The development and eruption of teeth are a part of the child's total development. Dental developmental schedules are used as indices of growth and maturation during childhood since teeth develop and erupt in characteristic sequences and within predictable age ranges.[11, 13,17,23]

Serial radiographic studies of the dentition provide very critical and useful methods for appraising the intra-alveolar dental development throughout the various developmental stages of the

teeth.[14] The radiographic evaluation of intra-alveolar growth and calcification of the dentition provides a valuable indicator of dental age and serves as an index of the over-all maturation of a child.

By comparing the physical measurements of a child with the measurements of healthy children over a period of time, it is possible to determine whether he is progressing toward maturity at an average rate.

Height and weight are the physical manifestations of growth and development which are probably utilized most in diagnostic procedures, and in the assessment of growth and development. Body weight is probably the best index of nutrition and growth because it sums up all increments in size.[1,20,23]

Although there are individual patterns in physical manifestations, certain trends in the rate of growth are common to all children. The different stages of the life cycle exhibit different rates and trends of growth. When evaluating growth and development by means of physical measurements, many factors which introduce variability into growth trends and rates should be considered. Tables are available which provide mean height and weight measurements for sex age groups. These tables provide a guide for evaluating individuals in reference to the pattern of growth of a group similar to the child being evaluated, since a child normally maintains his relative pattern of growth as compared to his age group.[1,23]

Many investigators [3,5,6,10,18,21] have studied the relationship between the dentition and various aspects of growth and development. The findings of these investigators, in general, support the theoretical contention that positive relationships exist in varying degrees between the maturation of various tissue systems, whereas other investigators[2,19] found low correlations between dental development and body growth. In this study an attempt was made to determine the nature of the correlations among dental, skeletal, height, weight, and chronological ages.

Materials and Methods

A total of fifty-six Caucasian males, between the ages of eight and twelve years, were selected from patients in the pedodontic and orthodontic departments, School of Dentistry, University of Pittsburgh. The following data were obtained from each subject: chronological age, a carpal radiograph of the left hand and wrist, a lateral head radiograph, height and weight.

The carpal radiographs were analyzed by comparing each radiograph with the standards of Greulich and Pyle.[9] For evaluation of the dental development, the norms of Nolla[14] were utilized. The height and weight data were evaluated by means of norms provided by Olson and Hughes.[15] These various physical indices of growth and development were evaluated and assigned age values. These age values were obtained by comparing the raw data and materials to normative age values and standards which are based on age and the stage of maturity. This method permits the expressions of growth and development to be based on the same qualities. Statistical analyses were applied to these physical index values to determine the nature of the correlations among them.

Findings

The dental ages ranged from 93 months to 158 months with a mean of 109.55 months; the skeletal ages varied from 70 months to 149 months with a mean of 129.46 months; the weight ages were from 83 months to 191 months with a mean of 133.66; the chronological ages ranged from 95 months to 144 months with a mean of

Table I
Correlation Coefficients
(Between all Age Variables)

Ages	Dental	Skeletal	Weight	Height
Skeletal	0.4616			
Weight	0.4810	0.7570		
Height	0.5630	0.7859	0.8145	
Chronological	0.6774	0.6882	0.5534	0.6657

119.26 months; and the height ages were from 88 months to 164 months with a mean of 129.46 months. The ranges for all age variables were greater than the chronological age range.

The correlation coefficients for these age variables (Table I) showed that each of these variables was positively correlated with all the other variables. In Table I, dental age showed the highest degree of correlation with chronological age (0.6774) and the lowest correlation with skeletal age (0.4616). Skeletal age revealed the highest correlation with height age (0.7859) and the lowest correlation with dental age (0.4616). Height age had the highest correlation with weight age (0.8145) and the lowest correlation with dental age (0.5630). Weight age revealed the highest correlation with height age (0.8145) and the lowest correlation with dental age (0.4810). Chronological age had its highest correlation with skeletal age (0.6882) and the lowest correlation with height age (0.5534).

Discussion

The correlation coefficients for the age variables studied showed positive correlation (ranging from 0.4616 to 0.8145) between each other.

The findings of this study support those of Hotz, Boulanger and Weisshaupt[11] in that the degree of association was closer between dental age and chronological age than between dental age and skeletal age.

A review of the correlation coefficients in this study indicated that chronological age was more highly correlated to dental age (0.6774) than were the other age variables. This observation indicates that in this study, chronological age is the best single predictor of dental maturity. Approximately one half of the variability in dental age may be accounted for by chronological age variability.

There was a high correlation between height age and weight age (0.8145). About two-thirds of the differences in the weights of these subjects can be accounted for on the basis of the differences in their heights.

The correlations did not fall into any obvious pattern. There appears to be a slight indication of a factor composed of skeletal age, height and weight. This factor might be termed the skeletal factor. We might hypothesize that the factors which control skeletal growth and development are also quite important in determining height and weight.

The growth of individuals is often irregular and this should be realized in applying norms of development based on central tendencies and variabilities of healthy children. Some aspects of growth and development for healthy

children may show a shifting pattern of growth, that is, a shift from high to average, to low and back to average again when comparing a child with his maturing age group. Therefore, correlation of these aspects of growth and development often will not show the degree of correlation which theoretically exists between these different areas of growth and development.

It should also be pointed out that only sample evaluations in various areas of growth and development were obtained in this study. A more complete appraisal of the entire skeleton rather than the carpal bones alone, and the evaluation of the entire dentition, rather than just the mandibular posterior teeth, might improve the degree of correlation between these variables.

It is felt that this study served to point out the need for more extensive investigation, the need for more current tables and norms representing more geographical areas, the need for a larger and more representative sample of subjects from both sexes and the need for more precise methods of appraising growth and development.

Conclusions

The purposes of this study were to review the various indices of over-all growth and development used in orthodontic diagnosis and to determine statistically the nature of the interrelationships among these various indices. The indices chosen for investigation were dental development, skeletal development, height, weight and chronological age.

The correlation coefficients between dental, skeletal and chronological ages (with r values ranging from 0.4616 to 0.6882) showed a moderately high association, but not as high as reported by Demisch and Wartmann[3] (0.83 to 0.89 for males) in their study of the calcification of the mandibular third molar as related to skeletal and chronological ages.

The findings of this study support those of Hotz, Boulanger and Weisshaupt[10] in that the degree of association was closer between dental age and chronological age than between dental and skeletal age.

Chronological age was more highly correlated with dental age than any of the other variables studied. Skeletal age, height and weight showed a slight tendency to form a factor which is possibly controlled to some degree by the same forces of growth and development.

Further investigation of growth and developmental relationship was indicated for a larger number of subjects of both sexes, and in wider age ranges, particularly in the higher age ranges of males. This study also indicated the need for more recent and adequate standards and norms and for more precise methods of evaluation of these expressions of growth and development.

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Growth Concepts*

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The method of superimposing tracings of serial lateral cephalometric x-rays to demonstrate growth changes and orthodontic treatment results depends upon one's concept of human head growth.

While we must accept the thesis that no absolute fixed reference point exists from which the pattern unfolds, we may describe growth changes in terms of the movement of parts relative to each other. The dangers involved are that the selection of reference landmarks may lead to errors in interpretation.

The time-honored concepts of human facial growth as advanced by the cephalometric studies of Broadbent[1] and Brodie[2] have long laid the foundation of our understanding of facial pattern development. At the same time, the accepted methods of superimposing serial tracings tend to mask the manner by which the growth of craniofacial structures influence the horizontal and vertical unfolding of the face and, more important, how this growth affects the profile.

The method to be presented for consideration, shown in Figure 1, differs from the Broadbent and Brodie techniques in that serial tracings are registered at basion orienting the anterior cranial bases parallel. The advantage of registering at basion is that serial tracings superimposed in this manner graphically illustrate the contribution of growth systems to depth and height development.

In order to develop the rationale upon which this method is based, a review of some familiar concepts is necessary. Let us first consider the concept that essentially the head is composed of two bones, the craniomaxillary bone and the mandible; further, that the spatial positioning of the maxillary denture is dependent not only upon the growth of the maxilla and associated bones housing the teeth, but also upon the growth of the cranial base to which it is attached. Todd aptly stated this thought long ago when he wrote, "The face halfted as it is to the cranium, is carried forward by the expanding brain case." Growth of the cranial base carries the maxillary teeth upward and forward away from the vertebral column while the mandibular teeth are carried downward and forward by mandibular growth. Figure 2 is a simple diagram illustrating this concept.

One important finding disclosed previously[3] was that from eight years of age the distance between basion and articulare does not change. This means that using basion as a starting point, the mandible is positioned a set distance forward to basion and from there it is a running race, the maxillary denture being carried upward and forward by the cranial base, away from the vertebral column, the mandibular teeth carried downward and forward by growth of the mandible. If then there is to be normal occlusion there must be complete synchronization of growth, at least close enough to permit inclined planes of teeth to settle the occlusion into proper relationship. Any disharmony in the amount of growth and direction of growth will result in some

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degree of dysplasia.

In order to understand the vector of development affecting the spatial position of the maxillary dentition it is necessary that we consider the growth behavior of the anterior and posterior cranial base segments separately. The anterior cranial base to which the upper face is attached is usually delineated in cephalometric studies by sella and nasion. This is a misnomer, as most of us realize. The sphenoethmoidal suture ceases its development approximately at the age of seven years. After this time measurement between sella and the internal plate of the frontal bone shows little to no change. Further increment in the sella-nasion dimension appears to be appositional development of the frontal bone. In forty-seven cases studied[4], measurement between sella and internal plate of the frontal

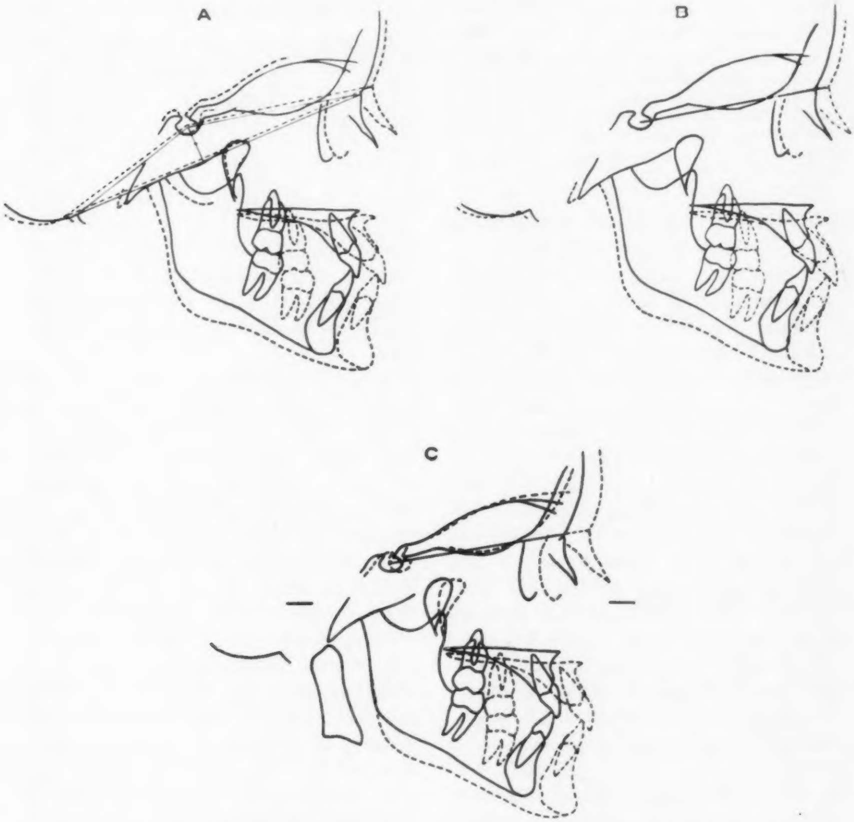

Fig. 1 Techniques of superimposing tracings of serial lateral cephalometric x-rays. "A" (Broadbent) bases of Broadbent-Bolton triangle parallel, registration at R; "B" (Brodie) S-N planes superimposed, registration at S; "C" (Coben) Registration at Basion, S-N planes parallel.

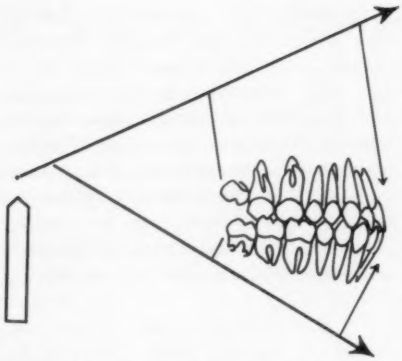

Fig. 2 General vectors of growth. Maxillary teeth carried upward and forward away from vertebral column by cranial base growth. Mandibular teeth carried downward and forward by condylar and ramal growth. Divergence of vectors permits vertical development of the face.

bone from ages 8 years ± 1 year to 16 years ± 1 year ranged from no change to a maximum increment of 2 mm, the mean being +0.5 mm.

Scott[5] states that foetal and early childhood development of the upper facial bones is dependent on growth of the anterior cranial base and nasal capsule, growth being predominantly sutural. He considers the pterygopalatine suture to be part of the same complex as the sphenoethmoidal suture and that when this suture ceases its activity at approximately seven years, so does the pterygopalatine suture. His contention is that additional anteroposterior development of the middle face after this suture closure is due to appositional bone development. Thus, there appear to be two phases of facial growth, the first being sutural until the age of seven years, the second, primarily surface apposition and internal resorption. This theory disagrees with the accepted thought that the maxilla and its teeth are pushed forward by sutural growth to make room for the erupting second and third molars; rather, that after seven years, normal eruption of teeth is downward and forward and the concomitant build up of alveolar process makes room for the eruption of the molar teeth.

Let us now consider the posterior cranial base, in particular the spheno-occipital synchondrosis. Here we have the most neglected growth site of all facial growth studies but whose influence, together with condylar and ramal growth of the mandible, probably establishes the entire pattern of the unfolding of facial development.

Growth in the spheno-occipital synchondrosis continues through the pubertal period. It is important to emphasize that not only is there growth in this area, but also consideration must be given to the direction in which this growth is expressed. In one individual such growth may be primarily horizontal, carrying the maxilla and its denture in a forward direction; in another more vertical, contributing primarily to vertical development of the face.

Another interesting finding in the eight to sixteen year growth study to which reference has been made was that, while males exhibited greater overall growth in the posterior cranial base, the contribution of this growth to the depth of the face was the same in both males and females. The explanation lay in the direction of growth. Growth of the posterior cranial base in the male was expressed more vertically, thus contributing more to vertical than horizontal development. One of the basic sex differences in facial growth during puberty is the greater vertical development of the male face. Thus we are not only interested in growth, but also in the direction of growth.

Unfortunately one cannot draw a line from basion to sella along the long axis of the posterior cranial base and expect that this will be the vector of growth of the synchondrosis. The direc-

tion changes, oftentimes more vertical in males, but is unpredictable. It is this change in the directional growth of the synchondrosis that one is measuring when one speaks of a change in the angle of flexure of the cranial base. Attention is now directed to the mandibular vector of growth. If we refer to basion we must first consider the forward positioning of the mandible and from then on it is mandibular growth that is the determinant of the spatial positioning of the mandibular denture.

Just as it was important to emphasize the direction of growth of the spheno-occipital synchondrosis, so it is with condylar and ramal growth of the mandible. In the foetus the direction of condylar growth is more horizontal contributing more to depth of the face to create arch length for the developing dentition. After birth, during eruption and development of the dentition, the direction becomes more vertical that now growth contributes more to the necessary vertical development of the face making room for tooth eruption[6].

It is apparent that there must be a synchronization in the amount of growth and the direction of growth of the cranial base and mandible if there is to be a normal denture relationship. Growth of the spheno-occipital synchondrosis carries the upper face and denture upward and forward away from the vertebral column; growth of the mandibular condyle and ramus carries the mandibular body and denture downward and forward. Between the two vectors space is created for the vertical unfolding of the face. Any excessive deviation in the amount or direction of growth without compensatory changes will result in dysplasia.

Now to make the bridge to a method of superimposing serial tracings to correlate with our concepts of the unfolding of facial growth. This can be done by registering on basion with anterior cranial bases parallel, the anterior cranial base delineated by the orbital roofs and cribiform plate, or the S-N plane, which for practical purposes bears an almost constant relation to the former. The concept of superimposing anterior cranial bases parallel stems first from the fact that the anterior cranial base after approximately age seven is stable, and second, from the thesis that the sight axis of the eye must bear a relatively constant relation to the skull and postural position of the head.

A few cases will demonstrate the value of the method described. Figure 3 illustrates the growth behavior of two males, approximate age span eight years to sixteen years. The vertical development of both profiles as measured from nasion to menton was almost equal; however, each achieved vertical development by different processes. "A" obtained vertical development in the lower face by condylar growth permitting substantial eruption of the dentition. Growth of the posterior cranial base segment having been expressed in a horizontal direction contributed nothing to vertical development. "B" achieved vertical development primarily by vertical growth of the posterior cranial base segment with some small additional vertical change due to condylar growth; most of the vertical change occurred in the upper face with little eruption of the dentition. When horizontal change of the profile is analyzed, "A" shows the combined effect of horizontal growth of the posterior cranial base plus apposition on the frontal maxillary surface. The depth increment in the lower face is primarily due to increase in the length of the mandibular body, condylar growth contributing to vertical rather than horizontal development. Depth development in "B" appears to be primarily due to apposi-

Fig. 3 Growth analysis. Basion registered, S-N parallel. Sectional analysis demonstrates posterior cranial base growth and mandibular growth. S-SN superimposed demonstrates frontal maxillary apposition.

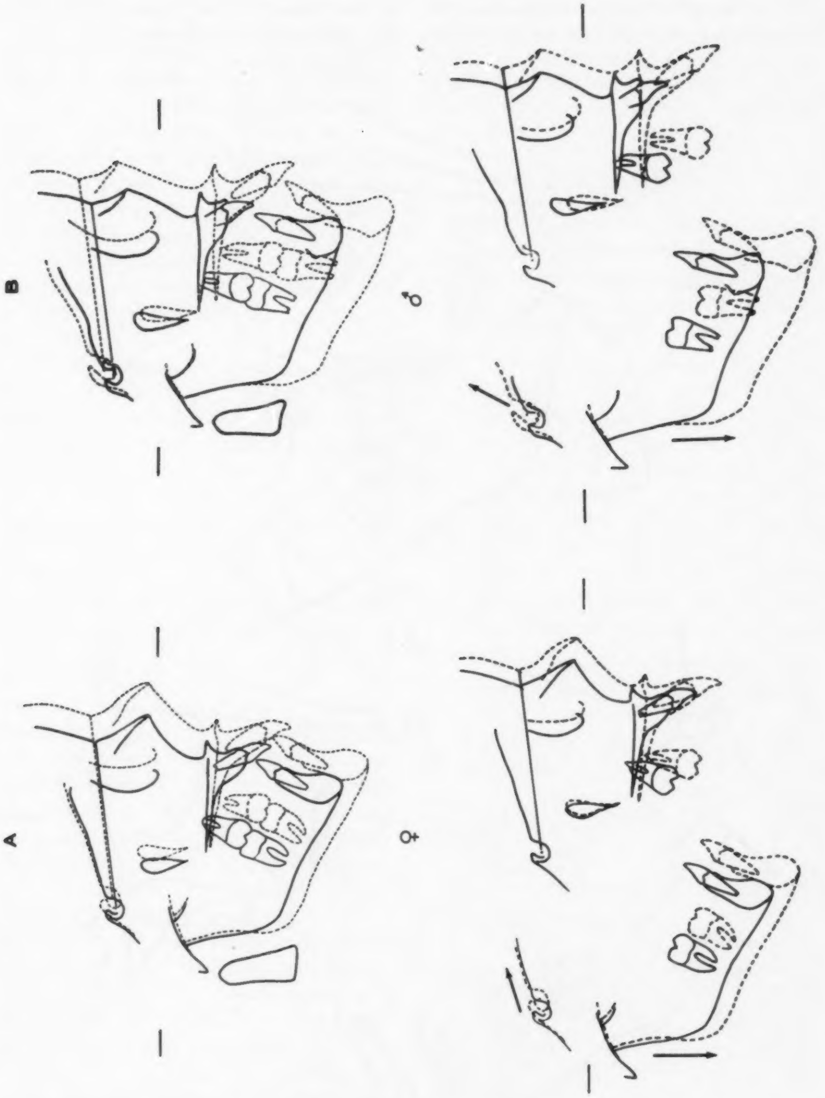

Fig. 4 Growth analysis of facial patterns exhibiting Class II, Division I malocclusion. Basion registered, S-N parallel. Sectional analysis demonstrates posterior cranial base growth and mandibular growth. S-SN superimposed demonstrates frontal maxillary apposition.

tion on the frontal maxillary surface plus a small horizontal component of posterior segment growth. In the lower face mandibular body growth was equal to that found in "A"; however, in "B" the chin point developed farther for-

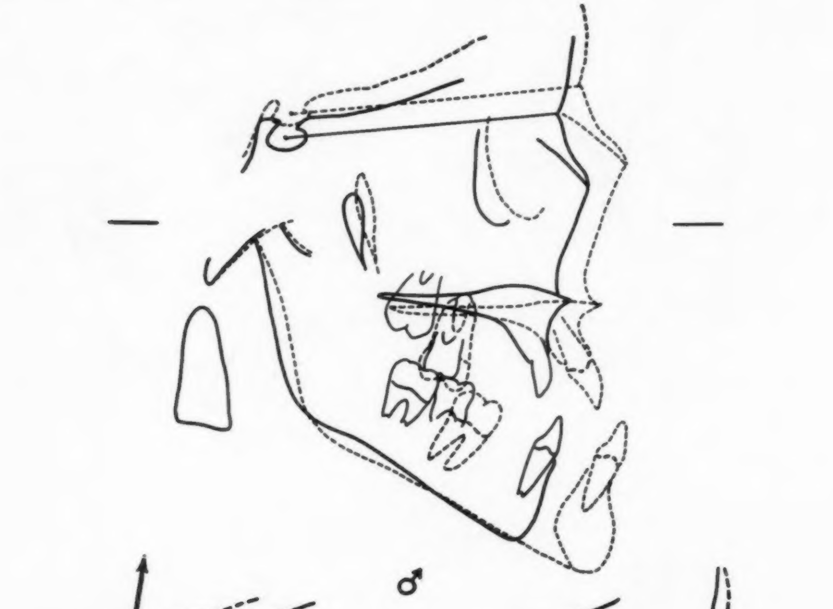

Fig. 5 Growth analysis of facial pattern exhibiting Class III malocclusion. Basion registered, S-N parallel. Sectional analysis demonstrates posterior cranial base growth and mandibular growth. S-SN superimposed demonstrates frontal maxillary apposition.

ward due to the addition of a horizontal component of condylar growth.

Figure 4 illustrates the facial growth behavior of a female "A" and a male "B" both exhibiting Class II, Division 1 malocclusions. Here we see that both faces exhibit similar patterns of development except for the greater overall vertical development of the male face as is generally expected. The vertical difference seen in the male face is due to a greater vertical increment of the posterior cranial base segment and a more vertical direction of condylar growth.

Figure 5 illustrates the growth behavior of a facial pattern exhibiting a Class III malocclusion where lower face prognathism became excessive with age. The case serves to illustrate the result of a disharmony in the direction of growth. The sectional superimposed tracings show a lack of depth development of the upper face. Although the amount of growth of the posterior cranial base was average, its direction was vertical and contributed little to horizontal development. This coupled with a deficiency in appositional development of the frontal maxillary surface resulted in a deficiency of depth increment. On the other hand, increase in the size of the mandibular body was closer to average. In addition there was an atypical horizontal expression of condylar growth to further increase the depth development of the lower face. This disharmony in directional growth of the posterior cranial base and condylar development appears to be the significant factor in the production of this dysplasia.

In order to present the growth concept, quantitation has been eliminated from the discussion; however, what has been illustrated can be quantitated by the coordinate method of analysis. The data of several of the illustrations have appeared previously in the literature[3].

It has been said that just about everything is known about the form and growth of the face in norma lateralis to the point where growth changes can be "predicted". Rather, it would be more appropriate to say that we are just beginning to decipher its complexity.

Summary

1. The method of superimposing serial cephalometric x-ray tracings by use of basion registration with anterior cranial base parallel, is discussed.
2. The method demonstrates the manner by which growth of the spheno-occipital synchondrosis carries the upper face and denture upward and forward away from the vertebral column, while condylar and ramal growth carries the mandibular body downward and forward. The divergence of the two vectors permits the vertical unfolding of the face.
3. The effects of disharmonies in the amount and direction of growth of craniofacial structures are graphically illustrated by this method.

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A Comparison Of Upper First Molar Rotation In Class II, Division 1 And Class I

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It has been commonly assumed that a Class II, Division 1 malocclusion is characterized in part by a forward drift in the maxillary denture, and that a diagnostic sign of such drift is the rotation lingually of the mesial portion of the upper first molar. It is presumed that this rotation takes place about the larger lingual root of the tooth. Moreover, it is charged that failure to restore this tooth to its proper rotation decreases arch length and develops faulty occlusion in the cuspid area. If mesial drift is usually accompanied by mesiolingual rotation of the first molar about the lingual root, a significantly greater amount of rotation in Class II, Division 1 cases would lend support to this concept of etiology.

REVIEW OF THE LITERATURE

Downs stated in 1938 that "mesial drift becomes effective as soon as the first permanent molars erupt and come into occlusion. Its function is to make up for proximal wear[4]. In considering an anterior component of force in the denture, the most important one by far is the erupting and occluding of the first permanent molars. Because of their anatomical form these teeth do not dissipate their stresses along their long axes. Their occlusal surface is not at a right angle to the tooth axis. Therefore, a vector of force is formed in a forward direction."[4]

Angle described the relation of the upper first molar to the lower first molar as the key to occlusion for the following reasons:

1. They are the first permanent teeth to be formed and to erupt.
2. They are the largest of the permanent teeth.
3. They come into the mouth unchanged by the presence of roots of preceding deciduous teeth.

Angle also considered that the upper first permanent molar would be more accurate in position than the lower first permanent molar because it erupts in a bone that is fixed in relation to skull anatomy.

Angle pointed out his belief for the steadfast and dependable position of the upper first permanent molar, and referred to it as a tool in the true basis of diagnosis.

Of interest is the provocative statement by Angle, "Now think of it! Was the dental apparatus made principally for the adornment of the face, and incidentally, possibly to eat with? Not in all living nature, either plant or animal, can I recall a single instance where utility in an organ is not placed before adornment."

He goes on to say that "the upper and lower first molars should be regarded as of equal importance in diagnosis only when they succeed in locking normally in their mesiodistal relations. But owing to the fact that the lower molar is dependent upon the caprices of the migratory mandible, it is in consequence less reliable than its steadfast antagonist. For this reason the upper first permanent molar be-

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comes the true basis of diagnosis[1].

Baldridge concluded in 1941 that "the upper first permanent molar assumes the same definite relation to the face and cranium in Class I and Class II malocclusions. These teeth can therefore be used as a basis for classification in Class I and Class II cases according to the Angle classification[2]."

In Strang's description of Hellman's findings, we see that the latter placed emphasis on "the importance of the mesiolingual cusp of the upper first permanent molar in maintaining and designating a normal relationship of the maxillary and mandibular arches. Its value lies in the fact that it is the largest of the cusps and is surrounded on every side, when in occlusion, by a cusp on the mandibular molar so that it resists displacement to the last degree, and frequently when the forces are such, it will pivot about its mesiolingual cusp rather than move uniformly[7]."

Strang concluded that "rotated molars usually indicate that abnormal pressure has been exerted upon the dental arch in which they are located, or upon the opposing arch, and hence such a malposition becomes an interest and aid in case analysis for classification and treatment.

"Rotation of these teeth more often appears in the maxillary arch than in the mandibular arch because of the mechanics associated with the occlusion of the mesiolingual cusp. This large well-defined structure rests in the central fossa of the mandibular molar and thus is completely surrounded by sloping walls.

"When abnormal or perverted muscular force tends either to throw the crowns of the maxillary teeth mesially, or the maxillary teeth are subjected to the constant functional stress of a distally located mandibular denture, this mesiolingual cusp on the maxillary molar resists displacement so strongly that it often maintains its normal location on the mandibular first molar long enough to cause the maxillary first molar to rotate bodily around this tenacious portion of its crown. When this occurs, the crown of the maxillary first molar will, of course, occupy a much greater space, mesiodistally, than when unrotated. Such a malposition will disturb the normal plane relationship of the maxillary premolars and canine on that side, producing an end-to-end contact with the mandibular teeth, or it may result in establishing a mesioaxial perversion of these premolar and canine teeth."[7]

Dewel states that "a diagnostic aid in analyzing mesial movement of upper posterior teeth is the characteristic rotation of the upper first molar that usually accompanies its forward displacement. The upper first molar is probably the most defamed tooth in the denture, in that its so-called immobile or stationary position has been referred to so often. This tooth, in fact, reacts to force, causing displacement almost as readily as any other in the dental arches. As it moves forward it tends to rotate, and, in so doing, it provides a diagnostic symptom that is not particularly characteristic of any other tooth.

"The upper first molar is rhomboidal in form and wider buccolingually than mesiodistally. This means that its greatest diameter is not through the contact areas, but instead on a line extending diagonally across the tooth from the distolingual cusp to the mesiobuccal cusp. These are also the cusps that become the contacting areas when the upper first molar assumes its characteristic rotation. Consequently, more space is required between adjacent teeth when the upper first molar is rotated than when normal contact relations are maintained in the dental arch."[3]

Friel, in an investigation of upper first molar rotation of thirty-four cases of first-year medical students with

TABLE I

FREQUENCY DISTRIBUTION OF UPPER FIRST MOLAR ROTATION IN CLASS I AND CLASS II, DIVISION I CASES

Degrees of rotation	Malocclusion			
	Class I		Class II-I	
	Right	Left	Right	Left
42-43	0	0	1	2
44-45	2	1	1	0
46-47	3	3	2	0
48-49	3	3	3	5
50-51	8	9	2	1
52-53	9	5	7	3
54-55	7	9	12	3
56-57	19	11	15	12
58-59	8	15	9	11
60-61	12	8	13	15
62-63	6	11	8	8
64-65	4	7	2	7
66-67	9	9	0	4
68-69	8	8	1	4
70-71	3	3	0	2

normal occlusion in the premolar area, and a second group of thirty cases with postnormal occlusion (Class II, Division 1), found a significant difference between Class I and Class II. Friel's figures were as follows:

Normal — 59.78°; postnormal — 52.12°, with a standard deviation of 5.43, a significant difference. The normal group on the right side measured 60°, on the left 57°. The postnormal cases on the right side measured 52°, on the left side 51°. He found a significant difference between normals and postnormals on both sides[5].

Friel's technique utilized a plexiglass plate with the model pushed up against it from the underside and held in position by a spring. The measurements were taken by placing a protractor on the topside of the plexiglass plate and reading the molar rotation through the protractor and plexiglass plate.

Method and Materials

The method utilized in this study was to compare Angle Class I cases and Class II, Division 1 cases that had full complements of teeth, in permanent dentition, with no peg laterals, supernumerary teeth or other tooth anomalies. Supernumeraries or deformed teeth might alter the position of the upper first molar and it would have to assume a position other than that which would be obtained by a normal eruption pattern. Accordingly, these cases were eliminated in the sample.

TABLE II

MEAN NUMBER AND STANDARD DEVIATION IN THE TWO COMPARED CLASSES OF MALOCCLUSION

	Class I		Class II-I	
	Right	Left	Right	Left
Mean	58.3 ± 0.64	58.9 ± 0.63	56.7 ± 0.55	59.2 ± 0.66
Standard Deviation	6.48	6.34	4.80	5.84

The starting models of seventy-seven untreated Class II, Division 1 cases and one hundred Class I cases were obtained that met the requirements mentioned. This would allow one hundred fifty-four comparisons in Class II, Division 1 cases and two hundred comparisons of Class I cases if one were to compare each side of the arch to the midline individually.

In an effort to eliminate parallax, photographs of the occlusal view of each maxillary arch were taken with the occlusal plane parallel to the film in the camera. Then a line was drawn on the photograph that connected the mesiobuccal and mesiolingual cusps of the upper first molar; a line was drawn for the midpalatal raphe. A comparison was made relating the rotation of each molar to the midpalatal raphe. Then the figures of the two malocclusions were compared. The results are summarized in Tables I and II.

In view of Friel's finding significant differences between the two sides, separate means for left and right were calculated in this study. Among the four mean values, the largest difference is obtained by comparing lefts and rights in Class II, Division 1. But this difference could easily arise due to chance and, as our data suggests, unlike Friel's mesiolingual molar rotation occurs no more frequently on one side than on the other, nor more often in Class II, Division 1 than in Class I.

Conclusion

Far from settling the matter of mesial drift, these findings permit several interpretations. Unless one discards them altogether in order to accept Friel's — based on a sample one-third the size of this one — it seems evident that mesiolingual rotation of the maxillary first molar is no more prevalent in Class II than in Class I. From this, however, we cannot adduce that maxillary mesial drift could not account for a certain number of Class II malocclusions. Such a conclusion could easily be countered by the assertion that a like number of Class I cases show maxillary mesial drift, accompanied by a corresponding amount of drift in the lower arch, maintaining normal mesiodistal molar relationships. Another possibility is that drift occurs, but molar rotation is not an inevitable consequence of it, so that measuring the latter phenomenon does not assess the former.

The truth of the matter is that the whole concept, so readily accepted in the past, is based on a priori assumptions. Reasonable as they may seem, they have never been substantiated by objective observations. Many factors other than drift could account for molar rotation and for perverted axial in-

clinations of cuspids. This study provides some basis for skepticism and suggests that the theory of mesial drift as an etiological factor in malocclusion needs better substantiation.

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